**Dentika Dental Journal**
Journal homepage: https://talenta.usu.ac.id/dentika

# Digital Design for Finger Prosthesis Template: A Case Report

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**ARTICLE INFO**

**Article history:**
Received 8 August 2025
Revised 5 October 2025
Accepted 21 November 2025
Available online December 2025

E-ISSN: 2615-854X
P-ISSN: 1693-671X

**How to cite:**
Cristandy GL, Fransisca FV, Ariani N. Digitally Designed Finger Prothesis Template for Prothesis Try-In. Dentika Dental Journal 2025; 28(2): 139-145

**ABSTRACT**

Prosthodontics is characterized by the incorporation of digital technology, which has transformed maxillofacial rehabilitation, providing quicker, more precise, and patient-friendly options. Therefore, this case report aimed to describe an alternative to traditional wax-up methods during the fabrication of a finger prosthesis using a digital workflow. Computer-aided design and manufacturing technology was a critical component in the rehabilitation of a 36-year-old male patient who suffered a loss of the right index finger due to trauma. Using an intraoral scanner, a digital scan of the afflicted area and the contralateral finger was acquired. To create the template design, the contralateral finger was mirrored and digitally sculpted using Autodesk Meshmixer software. A Phrozen LCD resin 3D printer was adopted to manufacture the finished design after being processed by nesting software. The template obtained was tried for anatomical accuracy, fit, and compatibility with the residual stump. The results showed that the method provided acceptable aesthetics and clinical fit while minimizing the number of patient visits. Integration of digital technology into the design was essential for achieving superior outcomes in finger prosthesis fabrication, which improved reproducibility, time efficiency, and patient comfort. In conclusion, the method proposed may serve as a realistic option in prosthetic rehabilitation, particularly for partial finger defects.

**Keywords**: Computer-Aided Design, Finger Injuries, Prosthesis Design, Maxillofacial Prosthesis

**ABSTRAK**

Penerapan teknologi digital dalam prostodonsia telah merevolusi rehabilitasi maksilofasial dengan menyediakan opsi yang lebih cepat, akurat, dan nyaman bagi pasien. Studi kasus ini menggambarkan alternatif metode *wax-up* tradisional untuk alur kerja digital. Teknologi *computer- aided design and manufacturing* digunakan dalam rehabilitasi pasien laki-laki berusia 36 tahun yang mengalami kehilangan jari telunjuk kanan akibat trauma. Menggunakan pemindai intraoral, pemindaian secara digital dilakukan pada jari yang diamputasi dan pada jari tangan kontralateral. Pada tahapan pembuatan desain *template* protesa, jari kontra lateral ditiru dan dibentuk secara digital menggunakan perangkat lunak *Autodesk Meshmixer*. Desain akhir dicetak menggunakan *3D Phrozen LCD resin*. Hasil *template* jari yang dicetak dicobakan untuk akurasi anatomis, kesesuaian, dan kompatibilitas dengan sisa jari. Metode ini memberikan estetika yang memadai dan kesesuaian klinis sekaligus meminimalkan jumlah kunjungan pasien. Penerapan teknologi digital dalam desain dan produksi protesa jari meningkatkan reproduksibilitas, efisiensi waktu, dan kenyamanan pasien. Metode yang diusulkan dalam artikel ini dapat menjadi pilihan dalam rehabilitasi menggunakan protesa, terutama untuk cacat jari sebagian.

**Kata kunci**: *Computer-Aided Design* CAD/CAM, Trauma Jari, Desain Protesa, Protesa Maksilofasial


http://doi.org/10.32734/dentika.v28i2.22411

## 1. Introduction

The need for humans to replace missing body parts with artificial prosthetics is longstanding. Trauma has been the cause of finger amputations, resulting in functional disability, which has a psychological impact. In an event where surgical reconstructions are impossible, finger amputation will be the choice of treatment [1,2]. According to Mehta's study, 86.9% of upper limbs and 52.9% of lower limbs were amputated due to traumatic injuries. The loss of limbs emphasizes the need for prostheses as a rehabilitation strategy [3].

The loss of a finger can greatly impact an individual's quality of life in several key areas, including physical, psychological, social, and environmental aspects. Patients often face a decreased quality of life due to physical limitations, psychological distress such as depression and anxiety, as well as social challenges that arise from changes in appearance and functionality [4]. The aim of providing finger prostheses is to restore the shape to the normal appearance. In order to achieve a normal and original resemblance, the making process should focus on the shape, texture, size, and colour details of each part of the missing finger [5]. These prostheses are used to replace missing parts or areas of hard and soft tissue and are expected to regain the function [6,7]. The procedure of making a finger prosthesis includes several steps which are complex. It can occasionally be uncomfortable for the patient, and largely depends on the expertise of the team comprising the technicians/technologists [8]. Conventional methods are labor-intensive, technique-sensitive, and time-consuming, relying on manual impression-taking, molding, and sculpting. In contrast, digital methods streamline design and fabrication through precision scanning, automation, and 3D printing, significantly reducing complexity and production time as well as enhancing customization, accuracy, and overall function [9].

Recent advancements in Computer-Aided Design and Computer-Aided Manufacturing (CAD/CAM) and the application in the technology of Prosthodontics offer an alternative for construction and design, as well as new materials and technologies. It addresses the need to reduce production costs, reduce visit times, and improve patient accessibility [6]. A study showed that the production time of nasal prostheses, which was generally 8 hours, became 5 hours [10]. As a result, the use of digital workflow reduces the length of the manufacturing process and produces high-quality prostheses. Based on observation, the method can also be applied clinically [11]. This case report aims to describe a method to fabricate a finger prosthesis template by digital workflow as an alternative to conventional wax-up to reduce the number of patient visits.

## 2. Case Report

A 36-year-old male patient was admitted to the Prosthodontics Clinic of the University of Indonesia Dental and Oral Hospital in February 2024 with a previously amputated right index finger. The amputation had been performed in 2007 following an animal bite. At the time of the accident, the patient was rushed directly to the emergency room for attempted fusion. However, the finger became necrotic in 3 days, and the amputation had to be conducted 6 days after the accident. Following the amputation, the patient required psychological therapy to cope with the trauma. On examination in 2024, the overall health and attitude towards treatment were discovered to be good. The patient wished to have a finger prosthesis made to improve daily appearance.

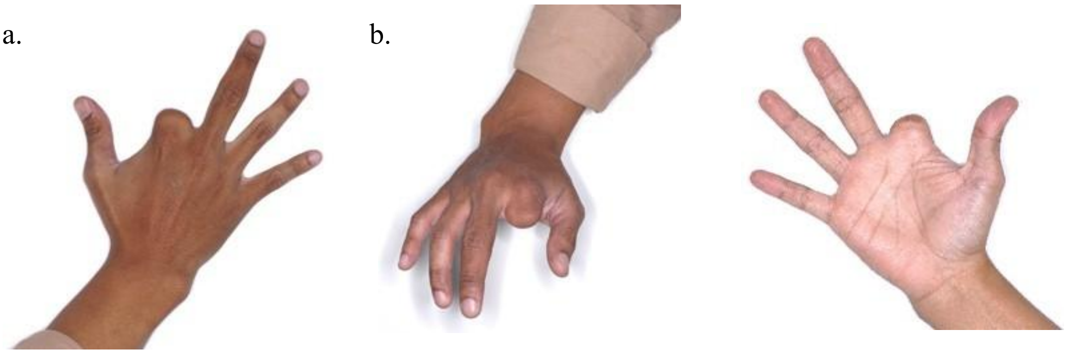


Figure 1. Patient initial presentation (a) Dorsal view, (b) Relaxed, (c) Volar view

Anamnesis and objective examination were conducted on the first visit. Based on the clinical examination, the amputation was performed on the right index finger, extended to the proximal phalanx area. A detailed assessment of the skin around the finger showed no signs of inflammation or infection, and the surrounding area appeared normal, but the stump was larger, as presented in Figure 1. Based on these results, the diagnosis was a traumatic partial amputation of the right index finger with a stable stump. The condition allows for a prosthesis to be placed on the stump. The prognosis for prosthetic rehabilitation was good, as the absence of infection and healthy surrounding tissues supported good adaptation, fit, and long-term use. After discussing with the patient, agreement was reached to provide a finger prosthesis in the rest position.

**Case Management**

Case management began with a digital scan of both the affected finger and the normal contralateral finger. A digital intraoral scanner (3Shape TRIOS 3 Move®, Copenhagen, Denmark) was used to capture data of both the normal finger on the contralateral side and the affected side (Figure 2a) in Standard Tessellation Language (STL) format, as detailed in Figure 2b and 2c

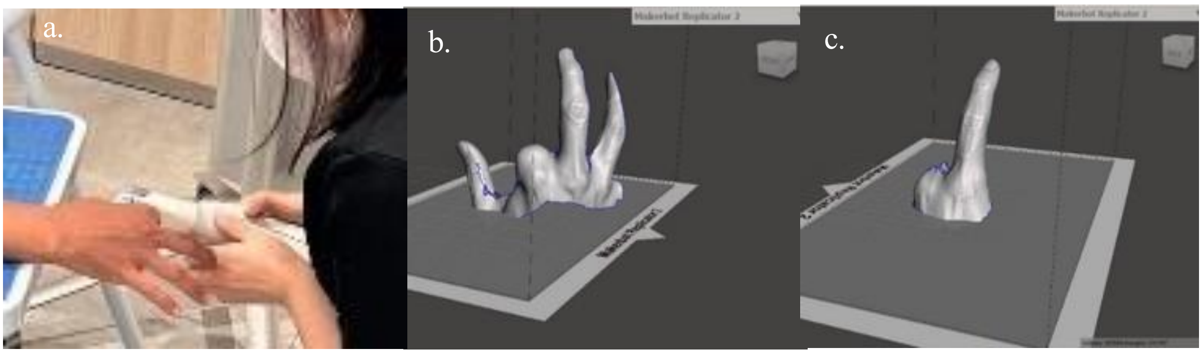


Figure 2**.** Digital impression taking (a) 3D scan of the finger, (b) Right side finger scan in STL format, (c) Left side finger scan in STL format

After obtaining data for the digital template process, the two STL files were successfully imported into the Autodesk Meshmixer 3D modelling software (Meshmixer® v2.1, Autodesk, Inc). This software was utilized to effectively invert the normal finger on the opposite side to facilitate the adoption as a prosthesis template of the patient (Figure 3) and was tried digitally on the amputated body (Figure 4).

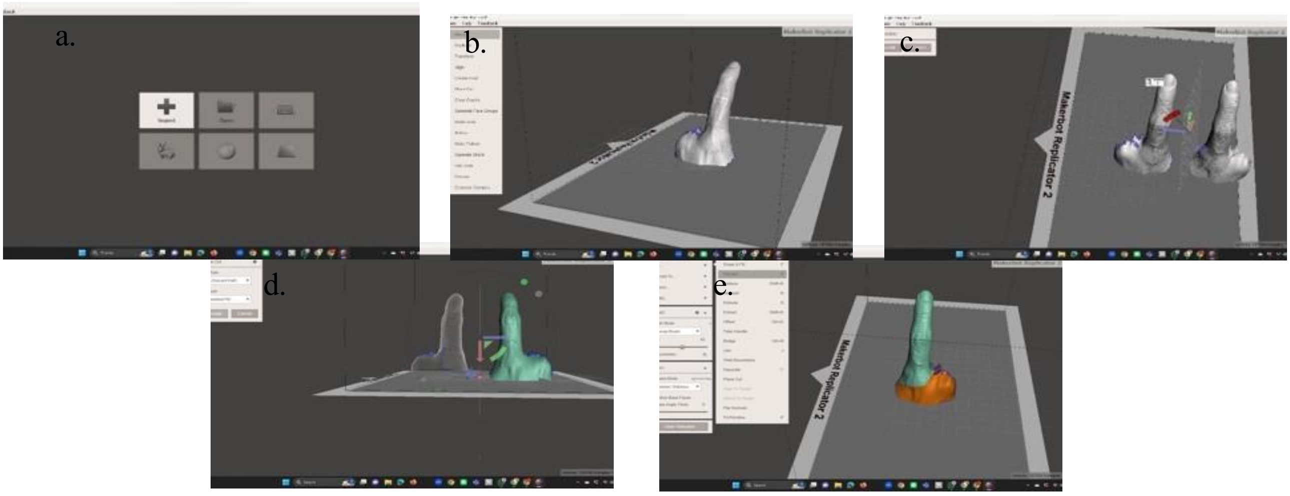


Figure 3. Mirroring steps (a) Opening the Meshmixer software, (b) Importing files. (c) Modifying the contralateral finger by using mirroring mode, (d) Erasing original scan, (e) Trimming the excess of the prosthesis template

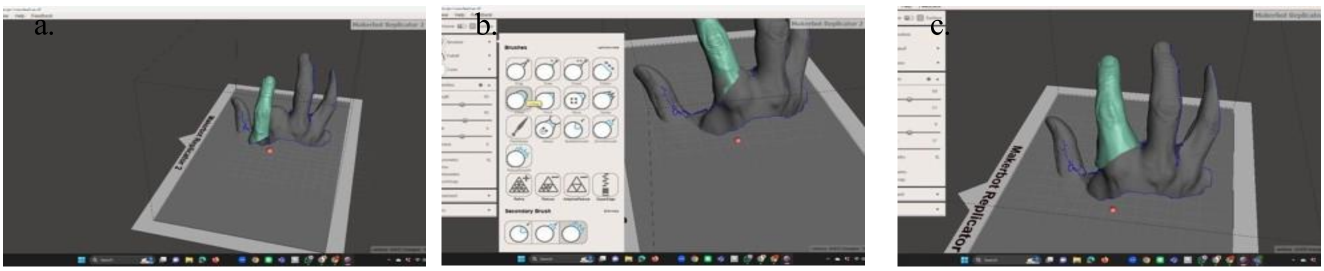


Figure 4. Digital try-in of prosthesis template (a) The model of the amputated finger was approximated to the template, (b) Adjust the template to fit the model of the amputated finger, (c) Good fit between the template and the model of the amputated finge

After the final template design was perfectly integrated with the surrounding elements, it was seamlessly extracted and imported into a nesting software (Chitubox Basic, V2.1, China) to make the base and support for the 3D printing process (Figure 5).

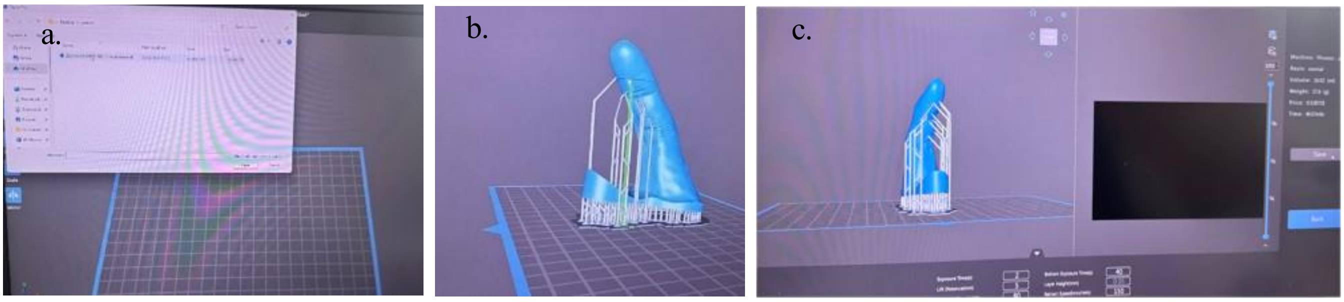


Figure 5. Process of making support for 3D printing (a) Importing Files to Chitubox Basic, (b) Setting the orientation and adding support manually, (c) Slicing stage before exporting the result to STL files

The file was extracted into a 3D printing machine (Phrozen Sonic Mighty resin 3D printer), while an inverted copy of the normal finger was 3D printed in gray resin (Rapid Resin, Monocure 3D), as detailed in Figure 6.

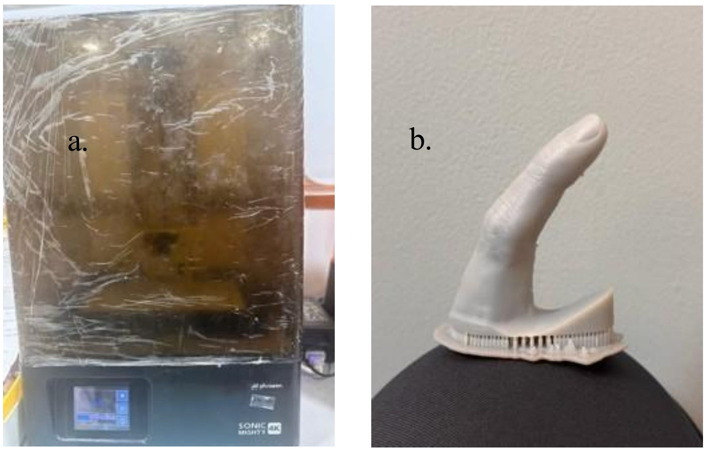


Figure 6. The 3D Printing Process (a) Phrozen resin 3D printer (b) Printing results in gray resin

After the finger model had been printed, the patient was scheduled for a second visit. This followed the first consultation, where the finger prosthesis template was tried on and adapted to the real finger (Figure 6). At this stage, the template was examined, and photographs were taken to ensure that the position and orientation were correct. The template was rechecked in terms of size, anatomy, and finger curvature in the resting position. The mirrored replica of the left finger model was observed to be accurate and lifelike in its natural resting state. During the try-in procedure, particular attention was given to the junction area between the template and the defect. The margin of the prosthesis template was carefully adapted to the contour of the stump to minimize visible transitions. To disguise the junction, the edge of the template was thinned and contoured to follow the natural curvature of the surrounding skin. The patient reported satisfaction with the overall fit, anatomical accuracy, and texture of the template, expressing comfort and confidence that the final prosthesis would provide an acceptable aesthetic result. Wearing a ring was recommended, should the margin of the prosthesis become visible in the final result.

Figure 7. The 3D printed finger template fitted on the finger (a)Dorsal view (b) Resting state (c) Volar view

## 3. Discussion

Patients born with congenital or acquired maxillofacial defects undeniably face significant psychological challenges due to both functional and aesthetic problems. To ensure the best outcomes, care from a multidisciplinary team that can collaboratively design the most effective treatment plan is essential. By executing rehabilitation in a carefully structured manner, functional and aesthetic outcomes are significantly enhanced. Individual patient factors may present some limitations, but the primary objective is to meet the physical and psychosocial needs comprehensively. The commitment lies in helping the patients achieve a state of near normalcy, thereby improving overall quality of life and well-being [12].

A study conducted over the past 20 years emphasizes a significant opportunity to improve the conventional, labor-intensive workflow in the production of maxillofacial prostheses. By adopting a simplified and predictable digital protocol that employs CAD/CAM technology, efficiency and patient comfort can be enhanced while simultaneously reducing costs. This transition is essential for advancing modern prosthetic practices [6]. Digital processes speed up production, reduce manual labor, and minimize turnaround time compared to traditional workflows [13].

Digital methods are revolutionizing maxillofacial rehabilitation by increasing efficiency and patient comfort [14]. Studies showed that the digital workflow for prostheses was both practical and straightforward. Digital workflows enable highly accurate design and fabrication, leading to prostheses that fit better and can be adjusted to individual patient anatomy [13,14]. Accurate impressions are critical for success, and intraoral scanners effectively capture skin texture for maxillofacial applications. However, the scanners may struggle to reproduce significant soft tissue defects, as the sensors often experience challenges in locating enough reference points in flatter areas [15]. This problem arose when an attempt was made to scan the dorsal region of the palm, and the patient moved slightly. The scan results from the scanned and inappropriately scanned areas cannot be stitched. In this case, strategies such as rescanning the affected area, dividing the scan into smaller regions, or using reference markers are applied to improve accuracy and achieve a complete digital model. Addressing the challenge can significantly enhance patient outcomes and prosthesis design for better fitness and comfort.

The digital workflow empowers clinicians to create precise, cast-free restorations that can be printed directly, thereby lowering treatment costs [16]. Traditionally, utilizing a physical cast is crucial for ensuring a precise fit and optimal marginal adaptation of a prosthesis before its placement [17]. However, this innovative approach enabled efficient printing of a prosthesis template for the patient's finger. The digital workflow streamlines the process of replicating printed prostheses, leading to significant savings in both time and resources [16]. Conventionally, fabrication of a finger prosthesis may require multiple visits and highly skilled labor-intensive procedures. The digital scan and 3D printing method used in this case allowed a reduction in treatment time and less dependence on labor-intensive procedures, as shown in several studies [6,10]. Based on observation, silicone prosthesis can deteriorate with use and needs to be replaced regularly.

The ability to produce a prosthesis without the hassle of repeated impression and wax-up is a remarkable advantage that enhances both efficiency and comfort, underscoring the value of adopting the recent techniques in modern practice. Therefore, integrating CAD/CAM technologies leads to a more consistent and reproducible result and improves aesthetic, comfort, and functionality [14].

Harnessing the ability of digital design for unilateral defects can enhance the result by applying techniques such as mirroring. This technique utilizes the area opposite the defect as an accurate design template [18]. The software superimposes, aligns, and customizes the finger design with the virtual soft tissue surrounding the defect. This was achieved by adopting a comprehensive scan of the patient that respects both the symmetry and the natural limits of surrounding tissue. The method not only ensures aesthetic balance but also provides a more harmonious overall appearance [19]. The 3D visualization and simulations help patients understand more about the treatment options and expected outcomes more clearly. A clinical report identified margin thickening as a significant drawback, with the thinnest margin being achieved at 400 µm [20]. However, the patient in this report expressed satisfaction with the overall result, particularly appreciating the natural appearance, anatomical symmetry, and the comfort of wearing the prosthesis.

A limitation of the digital workflow is its high initial cost due to the substantial investment required for equipment, software, and training for CAD designers, as well as steep technical learning curves [21]. To enhance accessibility, there is a pressing need to develop software that can automatically or semi-automatically generate prosthesis designs from scan data [22]. Furthermore, the open-source CAD software, specifically Autodesk Meshmixer 2.1 and Chitubox Basic, was adopted to address cost concerns. For the finger template, a Phrozen 4K 3D printer was selected because it is widely recognized as an entry-level LCD 3D printer that offers versatility and affordability for beginners in digital fabrication. Digital workflow can only cover certain steps, with a complete, fully digital solution for silicone prosthesis still developing. It is challenging to capture the details of the tissue and movement accurately, affecting the fit and aesthetics. Additionally, some conventional steps are often still necessary [21].

This case report shows that integrating digital technologies into the production of a finger prosthesis significantly enhances the overall process compared to traditional methods. By adopting a digital approach, excellent outcomes are achieved while reducing the number of appointments required for scanning, fitting, and contouring. The finger prosthesis template, expertly printed with a Phrozen 3D printer, was clinically tested and showed an impressive fit, allowing for easy reproduction when necessary. Furthermore, the template offered adequate coverage of the defect, blending with the surrounding tissues.

## 4. Conclusion

In conclusion, this case report outlined a workflow for utilizing 3D technologies to design and print a 3D-printed finger prosthesis template with satisfactory aesthetics. The method improved reproducibility and acceptance, potentially becoming an effective treatment workflow for patients with finger defects. By incorporating digital technologies into the manufacturing of prostheses, the process enhanced patient comfort, increased production efficiency, and reduced both costs and time. This progressive method helped in delivering superior outcomes for the patient.

## 5. Acknowledgements

## 6. Conflict of Interest

The authors declare no conflicts of interest related to this work.

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