International Journal of Dental Research and Allied Sciences
2023, Volume 3, Issue 1, Page No: 1-7

Available online at: www.tsdp.net

ISSN: 3062-3502

Case Report

Customized Prosthetic Solutions for Scleroderma-Induced Microstomia: A Semi-Digital Approach in Removable Partial Denture Fabrication

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Received: 02 February 2023; **Revised:** 10 April 2023; **Accepted:** 19 April 2023

ABSTRACT

Scleroderma is a chronic connective tissue disorder characterized by collagenous fibrosis, leading to the stiffening and contraction of the skin and mucosa. Most people with scleroderma experience Raynaud's phenomenon, where their fingers and toes become numb, tingling, and cold when exposed to stress or low temperatures. The fibrotic changes in the skin and soft tissues contribute to microstomia, a condition characterized by limited mouth opening, which poses challenges for both patients and dental practitioners. Common oral health complications associated with scleroderma include limited mobility of the lips and tongue, xerostomia, myofascial pain, gastroesophageal reflux disease, dysgeusia, and periodontal issues. Prosthetic rehabilitation management for patients with microstomia can be complex, as the reduced oral aperture often makes the insertion and removal of dentures difficult. This clinical report presents a semi-digital approach to prosthetic rehabilitation for 2 partially edentulous patients with scleroderma-induced microstomia. Intraoral scanning was used for impression-making, and 3D-printed models were generated. Both patients were successfully rehabilitated with conventional removable partial dentures. Intraoral scanning appears to be a viable alternative to traditional impression techniques and can be effectively used for impression-making in patients with microstomia.

Keywords: Scleroderma, Removable partial denture, Microstomia, Intraoral scan, 3D printing

How to Cite This Article: Özatik Ş, Saygılı S, Sülün T, Alan CB. Customized Prosthetic Solutions for Scleroderma-Induced Microstomia: A Semi-Digital Approach in Removable Partial Denture Fabrication. Int J Dent Res Allied Sci. 2023;3(1):1-7. https://doi.org/10.51847/XlJ1uvhGvu

Introduction

Scleroderma is a long-term connective tissue disorder characterized by collagenous fibrosis, leading to the thickening and contraction of the mucosa and skin. A significant number of individuals with scleroderma experience Raynaud's phenomenon, a condition where fingers and toes become cold, numb, and tingling in response to stress or low temperatures [1-3]. The fibrotic changes in the skin and soft tissues contribute to microstomia, a clinical condition that restricts mouth opening, making routine oral functions challenging for patients and complicating dental procedures. Oral health issues frequently observed in scleroderma patients include restricted movement of the lips and tongue, xerostomia, myofascial pain, gastroesophageal reflux disease, dysgeusia, and periodontal complications [4-7].

Managing prosthetic rehabilitation in patients with microstomia presents unique challenges due to their limited oral access. Many of these individuals struggle with inserting and removing dentures, making conventional prosthetic approaches difficult. Impression-making is particularly complex, as standard stock trays may not fit within the reduced oral cavity, necessitating modifications in technique [8, 9]. Various methods involving sectional impression trays have been explored with some success. However, an optimal approach for obtaining preliminary impressions in patients with microstomia remains unclear. Ultimately, the choice of technique depends on the clinician's expertise and preference [10-12].

In recent years, conventional analog impression techniques have been progressively replaced by digital technologies in routine prosthetic dentistry. Advancements in computer-aided technology have simplified impression-making, fabrication, and design of dental restorations, making these processes more accessible and efficient. Digital methods not only reduce procedural time but also offer high precision, repeatability, and ease of application in both chairside and laboratory settings [13-15].

A key innovation in this digital transformation is the introduction of intraoral scanners, which have significantly improved denture fabrication. These scanners eliminate the need for tray selection or adaptation, minimize the risk of cross-contamination, and remove the necessity for transferring impressions to a laboratory. Additionally, high-quality working models are no longer a strict requirement [16-18]. While CAD/CAM technology has been extensively studied for fabricating tooth- and implant-supported fixed prostheses, its application in partial and complete denture production remains relatively unexplored. One challenge of digital impressions in edentulous cases is the difficulty in capturing dynamic movements of soft tissues and the interference caused by saliva reflection, which can lead to inconsistent results [19-22].

For patients with scleroderma-induced microstomia, CAD/CAM technology may offer a practical alternative to conventional analog techniques. Digitally recording the denture seating area can be more efficient and less invasive than traditional methods that rely on sectional resin trays [23-25]. This report demonstrates a semi-digital workflow for fabricating removable partial dentures (RPDs) in two patients with microstomia.

Clinical reports

Case 1

A 37-year-old female was referred to the Department of Prosthodontics at the Faculty of Dentistry, Istanbul University, for the fabrication of a removable partial denture (RPD). The patient's primary concerns were difficulty chewing and reduced oral function because of missing teeth.

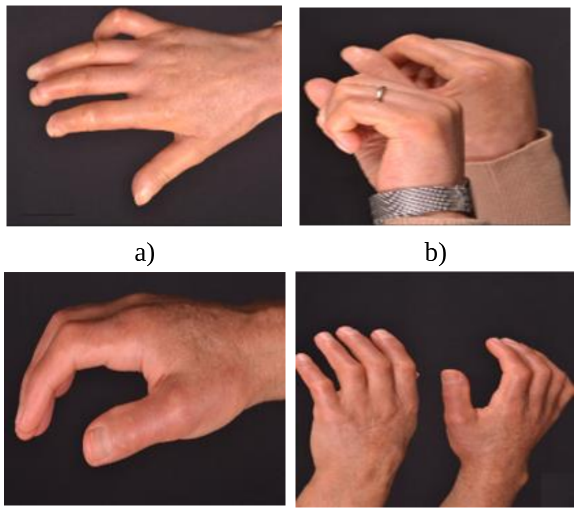
Her medical history indicated that she had been diagnosed with scleroderma at the age of 29, with no reported family history of the condition.

Upon extraoral examination, characteristic facial skin changes were observed. The skin appeared smooth and tight, with an absence of normal animation lines, giving the face a mask-like appearance **(Figure 1)**. Additionally, the patient exhibited sclerodactyly, a common manifestation of scleroderma, affecting her hands **(Figures 2a and 2b)**.

The intraoral assessment revealed bilateral posterior tooth loss in the mandible, corresponding to Kennedy Class II with one modification. Examination of the soft tissues showed a significantly thin alveolar mucosa and fibrotic lips.

a) b)

Figure 1. Smooth and tight facial skin resulting in a mask-like appearance; a) case 1, and b) case 2.



a) b) c) d)

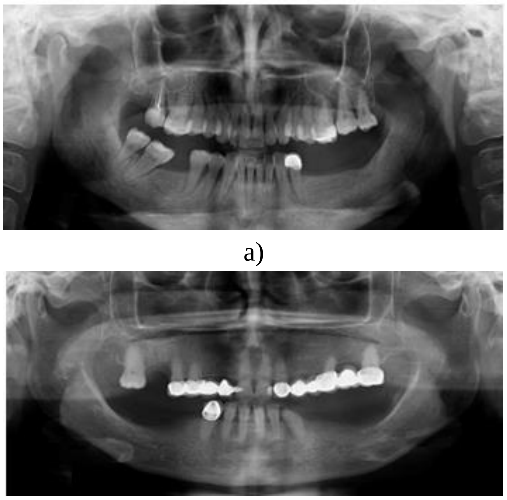
Figure 2. Sclerodactyly; a, b) case 1, and c, d) case 2.

A panoramic radiograph **(Figure 3)** displayed an overall widening of the periodontal ligament in multiple teeth, though no major periapical abnormalities were detected. The vertical occlusal dimension was within acceptable limits.

The patient's mouth opening was notably restricted, measuring around 25 millimeters **(Figures 4a and 4b)**. According to the classification outlined by Naylor *et al*. [24], this condition falls under severe microstomia, defined as a maximal mouth opening of 30 mm or less.

Additionally, salivary secretion appeared to be diminished.

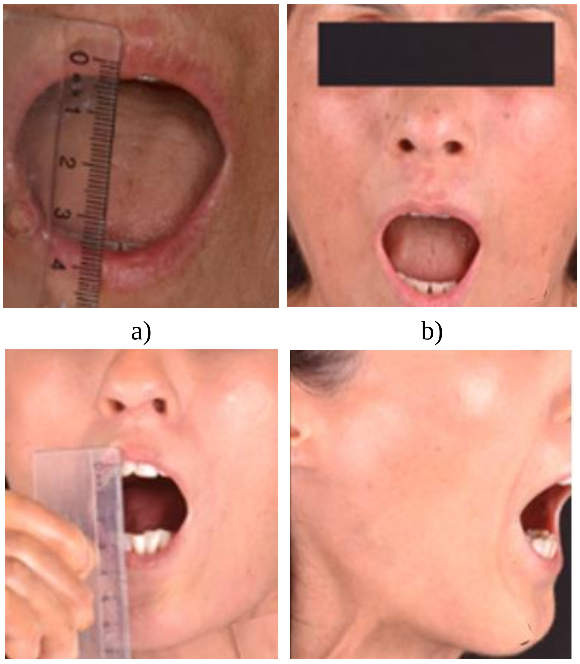
A comprehensive oral examination was conducted before initiating the impression procedure to assess the necessity of any tooth modifications. The patient's remaining teeth, intended to serve as retainers, exhibited natural undercuts and guide planes along the enamel surfaces.



a)

b)

Figure 3. Panoramic radiographs; a) case-1, and b) case 2.



a) b)

c) d)

e)

Figure 4. a) Limited mouth opening around 25 mm, b) Lateral view of tight mouth opening, c) Limited mouth opening around 30 mm, d) Tight mouth opening and fibrotic lips, and e) Difficulty in placing the intra-oral tip of the scanner in limited mouth opening.

Case 2

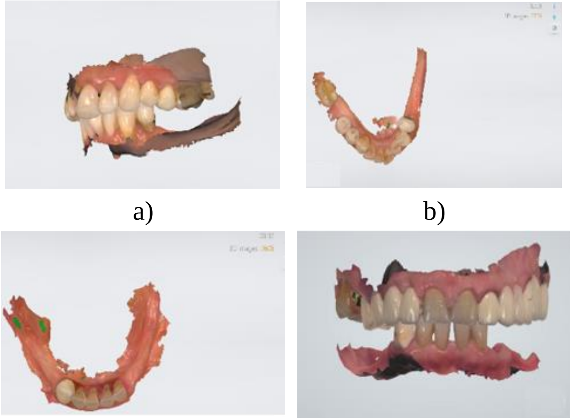
A 51-year-old female was referred to the Department of Prosthodontics, Faculty of Dentistry at Istanbul University for the fabrication of an RPD. The primary concerns expressed by the patient were difficulty in chewing and compromised oral function because of missing teeth.

The patient reported experiencing symptoms of scleroderma since the age of 22 years. An external facial examination did not reveal any distinct scleroderma-related signs **(Figure 1b)**. However, the patient exhibited Raynaud's phenomenon in her hands, characterized by pale fingers and restricted movement **(Figures 2c and 2d)**.

An intraoral assessment showed bilateral mandibular edentulism (Kennedy class I) along with tongue stiffness. The mucosal tissues in the edentulous areas demonstrated adequate resilience. The lips appeared taut and lacked flexibility. The salivary flow was visibly reduced. Despite deformities in the hands and restricted mouth opening, the patient's oral hygiene was well-maintained. A periodontal evaluation indicated no significant tooth mobility or periodontal pockets.

A panoramic radiograph **(Figure 3)** revealed crestal bone resorption without any major periapical abnormalities. The patient was diagnosed with severe microstomia, defined by a maximum mouth opening of 30 mm or less, following the criteria outlined by Naylor *et al*. [24] **(Figure 4)**.

The available prosthetic options for replacing the missing posterior teeth included an implant-supported fixed partial denture or a conventional RPD. The patient opted for the conventional RPD treatment plan.



a) b) c) d)

Figure 5. Intra-oral images; a, b) case 1, and c, d) case 2.

a) b)

Figure 6. The simple hinge on the mandibular printed cast easily fixes to the maxillary cast

Digital impression procedure

To begin the impression process, an attempt was made to use the smallest available stock tray (No. 1, Medesy, Maniago, Italy). However, due to the presence of microstomia and the fibrotic, non-flexible soft tissues, achieving proper tray placement and cheek retraction with a dental mirror was not feasible. Given these limitations, conventional impression-making techniques were deemed impractical, leading to the decision to use an intraoral scanner for both patients.

For digital impressions, a 3Shape Trios3 intraoral scanner (Copenhagen, Denmark) was employed to obtain three-dimensional scans of both dental arches. Careful attention was paid to the scanner's movement and positioning within the oral cavity to ensure accurate image capture **(Figure 4e)**. Participants were instructed to remain still during the scanning process to prevent any displacement of the edentulous tissues. The first patient's scan was completed within 8 minutes, capturing 4,225 images, while the second patient's scan took 12 minutes, generating 3,969 images **(Figures 5a–5d)**.

The collected occlusal scans were then transferred to specialized software for processing, preparing them for fabrication using stereolithography (SLA) 3D printing (Formlabs 2; Formlabs, Somerville, USA). The working models were printed with an accuracy of ± 25 μm using Formlabs model resin (Formlabs, Somerville, USA). A digital hinge mechanism was incorporated into the STL files, ensuring the printed casts could be precisely aligned for further processing **(Figure 6)**.

Next, a dental surveyor (Bego Paraflex Surveyor, Lincoln, USA) was used to analyze the models, and the removable partial denture (RPD) design was finalized. The frameworks were cast from chrome cobalt molybdenum dental alloy (Wironit LA; BEGO, Bremen, Germany) **(Figure 7)**. After confirming the intraoral fit of the frameworks, artificial teeth (Ivoclar Vivadent AG, Schaan, Liechtenstein) were arranged for try-in. Once verified for aesthetics and functionality, the dentures were processed using heat-polymerized polymethyl methacrylate denture base resin (Meliodent; Bayer UK Ltd, Newbury, UK) and delivered to the patients.

At the one-year follow-up, both individuals adapted well to their prostheses, with no need for relining. They reported no difficulties in using their dentures and expressed satisfaction with the results. Due to the COVID-19 pandemic, in-person follow-up appointments were offered but declined. Instead, the patients confirmed via phone that they were experiencing no complications with their removable partial dentures.

a) b)

Figure 7. Conventional RPD frameworks fit on the printed cast.

This report highlights the application of a semi-digital workflow for removable partial denture (RPD) fabrication, utilizing an intraoral scanner for digital impressions in two cases.

Traditionally, intraoral scanners are not the preferred choice for capturing impressions in completely edentulous patients, as they struggle to accurately register displaceable soft tissues that are surrounded by saliva [1, 18]. Even in cases where the peripheral tissues possess adequate elasticity, the scanning process remains challenging due to unavoidable tissue movement caused by the passage of the scanner tip. However, when scanning partially edentulous patients, the presence of remaining teeth provides fixed reference points, making the digital impression process more reliable [1]. Despite technological advancements, the issue of accurately capturing mobile peripheral tissues has not yet been completely resolved, thereby limiting the full integration of digital scanning in removable prosthodontics [1]. Kim *et al*. [15] attempted to address this by using the scanner tip to stretch tissues during scanning, but this technique may introduce distortions in the final impression. Interestingly, in these cases, capturing details of the vestibular sulcus and other peripheral tissues was relatively straightforward, as these areas remained immobile due to fibrotic and sclerotic changes associated with scleroderma-induced microstomia.

One notable limitation encountered during the scanning process was the prolonged duration required for complete digital capture, averaging 8 minutes per patient. Due to restricted oral opening, only the scanner tip could be maneuvered within the oral cavity, necessitating additional time for data acquisition. The scanner was also utilized to retract the tongue, further aiding in the impression process. A study by Kattadiyil *et al*. [22] mentioned that digital fabrication techniques required an additional 3.5 hours compared to conventional methods when performed by predoctoral students. However, when compared to the time needed for sectional impression trays, the duration for digital scanning in these cases was relatively shorter.

Although software-related challenges were encountered during the scanning phase, the ability to delete and re-scan specific sections allowed for the creation of high-quality STL files, which were subsequently used for 3D printing. It is worth noting that this feature is not unlimited, emphasizing the importance of operator experience in handling intraoral scanners efficiently. In the current cases, the rigidity of oral soft tissues and reduced saliva flow contributed to the production of precise 3D-printed working models, which provided a solid foundation for the final prostheses.

Comparable semi-digital workflows have been documented in previous studies. Kim *et al*. [15] demonstrated the use of an intraoral scanner for obtaining a definitive impression in a patient with extremely tight reconstructed lips, recommending a hybrid approach where subsequent steps continued conventionally. Saygılı *et al*. [13] also described a case where preliminary impressions were obtained digitally in a microstomia patient. Similarly, Oh *et al*. [25] employed 3D-printed occlusal rims alongside an intraoral scanner to fabricate an immediate denture, with conventional techniques used in the final stages.

In these two cases, fully digital denture fabrication was not prioritized since both patients could insert their RPDs by rotating them at a 90-degree angle. To keep the process efficient and cost-effective, the removable denture frameworks were fabricated as monolithic structures and cast using conventional techniques, avoiding the complexity associated with sectional prostheses [1, 12]. At present, digital framework fabrication does not offer substantial benefits for such cases and would only increase treatment costs. Traditional RPD framework production continues to demonstrate better adaptation, superior fit, and greater accuracy compared to digitally manufactured alternatives [6, 16, 17]. Wu *et al*. [11] explored the potential of combining intraoral scanning and 3D printing to create conventional RPD frameworks, noting its promise for complex clinical cases in the future.

The incorporation of CAD/CAM technology in prosthodontics enhances patient comfort while minimizing the number of clinical appointments required. However, when dealing with toothless arches, the application of digital techniques does not necessarily simplify the fabrication process for complete dentures [19]. Additionally, post-fabrication relining may be necessary following digital denture production to ensure optimal fit and adaptation [6, 23]. In contrast, the fabrication of removable partial dentures (RPDs) is more straightforward and efficient when utilizing intraoral scanning. This is particularly true for patients with a stable jaw relationship and an existing vertical dimension in harmony with the opposing arch. For individuals with rigid soft tissues and restricted mouth opening, intraoral scanners can serve as a viable alternative to conventional impression techniques, offering improved practicality and enhanced patient comfort [1].

Conclusion

Advancements in CAD/CAM technology will revolutionize prosthodontics once they enable precise digital recording of movable soft tissues for final impressions in edentulous areas. This will pave the way for a fully digital workflow applicable to all patients. Based on clinical observations from both microstomia cases, it is recommended that manufacturers develop smaller intraoral scanner tips to accommodate individuals with restricted mouth openings, such as those affected by microstomia and similar conditions.

Acknowledgments: None

Conflict of Interest: None

Financial Support: None

Ethics Statement: None

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