Clinical application of an intraoral scanner and CAD/CAM system for a Kennedy class I partially edentulous patient

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Abstract: Traditionally, removable partial dentures (RPDs) have been made by using an elastic impression material and casting from a framework wax pattern on a refractory cast. In this short communication, the procedures for digitally fabricating removable partial dentures using an intraoral scanner (IOS) and additive manufacturing system (AM) are described. The adaptation accuracy of the RPD using IOS and AM techniques was evaluated subjectively as good or satisfactory.

Keywords: additive manufacturing, CAD/CAM, intraoral scanner, removable partial denture

Introduction

In recent years, digital technology has changed the method of fabrication not only for fixed prostheses but also removable prostheses. Compared with conventional manual steps, the digital procedure reduces treatment and laboratory time. Digital dentistry techniques consisting of computer-aided design (CAD), computer-aided manufacturing (CAM), and digital optical impressions have become increasingly widely used, and the manufacturing process for the fabrication of crowns and implant-supported prostheses has been modified dramatically. Most CAM system applications have been established on the subtractive style, applying a cutting instrument to mechanically mill the material and complete the coveted geometry following CAD instructions. Nevertheless, several drawbacks in the milling process have been confirmed [1]: (1) difficulty in cutting complicated shapes and undercut areas, (2) lack of recycling of most cutting chips, (3) incorrect cutting after cutting instruments wear down, and (4) long operating times. Currently, milling is not an optimal method for fabricating removable partial denture (RPD) frameworks. Additive manufacturing (AM), also recognized as three-dimensional (3D) printing, is the process of constructing the material layer by layer straight from 3D digital data. Recently, many studies have reported the application of several kinds of AM techniques in numerous dental disciplines [2]. In the clinical application of definitive impressions, it has, likewise, become possible to employ an intraoral scanner (IOS) as an alternative to the conventional impression-making use of an elastic impression material [3]. Digital optical impressions significantly improve efficiency, productivity, and accuracy.

This technique uses numerous scans whose images must be stitched together to capture the form of the teeth and soft tissue related to the design and manufacture of the RPD. However, capturing the soft tissue form under occlusal force and border molding during functional movements is impossible. The intention of making digital optical impressions using IOS and then AM framework constructions was more effective than using a conventional framework fabricated by casting from a framework wax pattern on a refractory cast [4]. The IOS technique can be useful in Kennedy class III situations in which there is support for teeth without a border molding [5]. For a case of distal extension in a Kennedy class I or II, the definitive impression using conventional analog impressions can produce better results compared to those with digital optical impressions. At this stage, altering the casting technique by sectioning the polyurethane 3D-printed cast might be the most appropriate method for such cases. In this manuscript, for a Kennedy class I partially edentulous patient, an RPD with a titanium alloy (Ti-6Al-4V) framework and I-bar clasp was made. The purpose of this manuscript is to describe the procedures for fabricating RPDs using digital technologies (IOS and AM) and conventional technology, altering the casting technique.

Clinical procedure

The patient was a 67-year-old female with a bilateral distal extension with missing teeth. Her chief complaint was difficulty during mastication due to the loss of the retainer in the existing mandibular RPD. The patient was examined in the conventional method for diagnosis and formulation of a treatment plan. The abutment teeth were arranged according to the RPD design as a pre-prosthetic treatment. Intraoral scanning of the patient’s hard and soft tissue was carried out with an IOS (TRIOS3, 3Shape, Copenhagen, Denmark) after tooth preparation, thus eliminating the requirement for a functional impression (Fig. 1). The scanner created a standard tessellation language (STL) data file of the master model, and an RPD was designed digitally using specialized software (DWOS Partial Frameworks, Dental Wings, Montreal, Canada) that simulated conventional laboratory work. At the outset, a digital survey instrument was used to decide the direction of the insertion/removal path automatically. Unsuitable undercuts were blocked out digitally after the survey line was mechanically drawn based on these calculations, and the locations for the placement of the retention cast tips were determined. Bilateral distal extension RPDs were designed with a lingual plate and I-bar claps on the left canine and right first premolar. Minor connectors, by which the acrylic resin denture base is attached, were made and joined along the drawing of the lingual plate and rests. The clasp assembly with I-bar clasp arms was drawn three-dimensionally, and the final virtual designs of the RPD framework were then finished. The framework was manufactured with 50 μm Ti-6Al-4V alloy powders (Ti-6Al-4V Grade 5, AP&C, Montreal, Canada) using laser sintering and a 3D printing machine (Concept Laser M2, GE, Boston, MA, USA). After finishing and conventional polishing of the framework were carried out, electropolishing was performed to complete the frameworks. The fitting accuracy, occlusal contacts, and retention of the 3D printed framework were evaluated in the patient’s oral cavity (Fig. 2). Although distal extension RPDs depend greatly on the residual alveolar mucosa for support, stability, retention, and bracing, it is impossible to capture the functional forms of soft tissue under occlusal force by optical impression using IOS. Thus, an altered casting technique was applied using the 3D printed framework. An acrylic resin for a custom tray (Trayesin II, Shofu, Kyoto, Japan) was joined to the metal framework on the cast, which was made from IOS STL data with 3D-printable polyurethane ink using a stereolithography (SLA) 3D printer (Carex P40, Straumann, Basel, Switzerland). The definitive impression was made using a silicone rubber impression material (Exafine, GC, Tokyo, Japan) under occlusal force, and then the definitive cast was revised in the laboratory (Fig. 3). The artificial posterior teeth were arranged, the auto-polymerized resin was polymerized, and the RPD was completed according to conventional methods. The CAD/CAM RPD was delivered to the patient. The patient’s satisfaction and masticatory function were improved by the RPD made with digital technology.
Discussion

Clinical reports regarding the fabrication of an RPD with CAD/CAM technology have been published by Williams et al. [6]. Definitive casts made from conventional impressions were scanned using a desktop optical scanner, and RPDs were fabricated by additive manufacturing. The fit of the RPDs for these patients was highly satisfactory. A small number of adjustments were necessary at the clasp assemblies, intaglio of occlusal rests, and minor or major connectors. It could not be determined whether a conventional lost-wax cast or 3D printed framework had superior fitness accuracy. However, both methods present clinically acceptable fitness. In this clinical case, to evaluate the fitness accuracy of the major connector, the gap distance between the major connector and the soft tissue was determined using the silicone film method used in the previous study [7]. The white silicone impression material (Fit Checker, GC Corp., Tokyo, Japan) was applied on the internal surface of the major connector. The white silicone layer was measured using a profile projector (V-16E, Nikon, Tokyo, Japan) at a magnification of ×50. A 200-500 μm gap in the center of the major connector was observed (Fig. 4). Diwan et al. [8] reported that the adaptation of cast frameworks and master models created a 300-600 μm gap. In terms of soft tissue displacement, the accuracy of fitting to the mucosa was similar to that of the conventional technique. The adaptation accuracy of the frameworks using IOS and AM techniques was evaluated subjectively as good or satisfactory. However, further developments in digital optical scanning are needed to easily make functional impressions of soft tissues for removable denture construction. In conclusion, the use of digital technologies (IOS and AM) and conventional technology, altering the casting technique, in RPD fabrication has many significant potential benefits.
Conflict of interest
The authors declare no conflict of interest.

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