ORIGINAL ARTICLE

The use of optical scanner for the fabrication of maxillary obturator prostheses

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Abstract

Introduction Maxillectomy following tumors or, more rarely, traumatic injuries may result in maxillary defects that may determine physical dysfunctions and functional impairment of speech and swallowing. The aim of our study was to present our experience in the management of post-maxillectomy patients by the use of obturator prostheses that were obtained by 3D digital casts via an intraoral scanner.

Methods Patients with maxillary defects following maxillary and/or palatal resection or maxillary traumatic avulsion were selected for this clinical study between 2015 and 2018. Five to 6 months after surgery, a definitive obturator prosthesis was fabricated thanks to an intraoral scanner. The following parameters of clinical outcome were considered: the absence of fluid leakage, the recovery of phonation, the recovery of swallowing, and personal satisfaction.

Results Twenty-eight patients (20 males, 8 females) fulfilled the inclusion criteria and were included in the study. Most patients had a maxillary and/or palatal defect because of a malignant tumor. On the whole, 93% of patients reported a complete absence of fluid leakage between maxillary sinuses or nasal fossa and oral cavity; most patients reported a good or complete recovery of phonation and swallowing.

Conclusions Digital technology for the fabrication of maxillary obturator prosthesis may be effective and useful. The reduced laboratory working time, the avoidance of the risk of aspiration of impression materials, and the overcome of the difficulties associated with whole tissue undercut impression are just some of the most important advantages that have been encountered thanks to this promising technology.

Keywords Maxillary obturator prosthesis · Digital · Intraoral scanner · Maxillectomy

Introduction

Maxillectomy following tumors or, more rarely, traumatic injuries may result in maxillary defects that may determine physical dysfunctions (such as oronasal fistulas and loss of support of the cheek and lip) and functional impairment of speech and swallowing [1–8].

Treatment of post-maxillectomy defects includes different options such as reconstructive surgery or rehabilitation with an obturator prosthesis. The treatment of choice will depend on each individual case, keeping in mind that the ideal technique for repairing such defects should fill the defect, allow close interlinking of the mouth and nose, restore the physiological functions of chewing, swallowing, and speech, and improve the facial appearance [1–5].

In particular, obturator prostheses still represent a valid option in selected patients, being simple, non-surgical methods to eliminate oronasal and oroantral communication, and to re-establish normal speech and maxillary dentition [1–6]. In fact, factors such as hospitalization, risk of complications, treatment time, systemic conditions, and patient refusal may make the surgical reconstruction of maxillary defects impossible [1–8]. Moreover, with obturator prostheses, tumor recurrence can be much more easily detected by direct observation of the postoperative maxillary cavity [1–8].

However, the building of obturator prostheses of maxillary defects can be challenging too, with conventional prosthetic methods often leading to problems that require substantial skill and experience to overcome; for example, the risk of

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aspiration while the impression is being made, difficulties associated with whole tissue undercut impression, and impaired impression due to reduced mouth opening after scar contracture or radiotherapy may be often encountered [1–8].

With the progressive improvements of electronic and digital technologies, and advanced manufacturing technology being applied in the field of dentistry and maxillofacial surgery, computer-aided design and computer-aided manufacturing (CAD/CAM) have been successfully employed in the fabrication of fixed dental prostheses and in data acquisitions for complete-dentition digital casts [4–8].

Therefore, the use of direct intraoral digital impressions can avoid errors more than a conventional impression can. Additionally, this allows to save time and to lower the cost of materials [4–8].

Most CAD/CAM systems used in dentistry are composed of a data acquisition unit (that collects the data from the oral cavity and then converts them to virtual impressions), a software for designing virtual impressions and eventually virtual restorations/prostheses, and finally a computerized milling device for manufacturing the restoration. The first two parts of the system play roles in the CAD phase, while the third is responsible for the CAM phase. CAD/CAM systems can be divided into closed systems (that offer all CAD/CAM procedures, including data acquisition, virtual design, and restoration manufacturing) and open systems (that allow the adoption of original digital data by other CAD software and CAM devices) [3–8].

Therefore, the aim of our study was to present our experience in the management of post-maxillectomy patients by the use of obturator prostheses that were obtained by 3D digital casts via an intraoral scanner.

Methods

Patients with maxillary defects following maxillary and/or palatal resection or maxillary traumatic avulsion were selected for this clinical study between 2015 and 2018. All participants gave informed consent. The two inclusion criteria were as follows: maxillary defects caused by maxillectomy or traumatic avulsion showing satisfactory healing at the surgical site and no indications of tumor recurrence and no plans for further surgical treatment; the maxilla had a partial defect, which resulted in oronasal communication.

The following data were recorded for each patient: age, gender, pathology responsible for maxillary and/or palatal defects, site and dimension of the defect (according to Brown classification), outcome.

Before surgery, whenever it was possible, a first maxillary obturator prosthesis was fabricated through conventional methods, and it was placed immediately after surgery. Five

to 6 months after surgery, a definitive obturator prosthesis was fabricated thanks to an intraoral scanner according to the following protocol.

The maxillary arch and palate, the maxillary/palatal defect, the mandibular arch, and the occlusal relationships were scanned using an intraoral optical scanner (TRIOS; 3Shape), and the 3D image was exported as a standard tessellation language (STL) file. The 3D images from the intraoral scanner were registered and merged to form a 3D digital cast of the maxillary defect containing the anatomic structures needed for the maxillary prosthesis. This included the defect cavity, maxillary dentition, and palate. A 3D digital cast of the mandibular arch and (thanks to the scanning of the occlusal relationship) a 3D digital occlusal relationship were obtained too.

In all patients, physical resin casts were produced by rapid prototyping from digital casts.

Based on the resin casts, maxillary prostheses were fabricated through conventional methods and evaluated in the participants to assess the clinical applicability of the digital cast (Figs. 1 and 2).

The following parameters of clinical outcome were considered: the absence of fluid leakage between maxillary sinuses or nasal fossa and oral cavity, the recovery of phonation, the recovery of swallowing, the personal satisfaction of the patient with the maxillary prosthesis. All patients had to rate every parameter from 1 (worst judgment) to 5 (best judgment).

Results

Twenty-eight patients (20 males, 8 females) fulfilled the inclusion criteria and were included in the study. Mean age was 60 years (range, 31 to 75 years old).

Most patients had a maxillary and/or palatal defect because of a malignant tumor (23 patients). The most common malignant tumor diagnosis was squamous cell carcinoma (10 patients), followed by adenoid cystic carcinoma (5), and adenocarcinoma (3). Table 1 resumes the underlying maxillary pathologies of the study population.

According to Brown classification, maxillectomy defects were class 2a in 17 patients (61%), class 2b in 6 patients (21%), class 2c in 3 patients (11%), and class 3a and 4b in 1 patient each.

Finally, subjective outcome results are presented in Table 2. On the whole, 93% of patients reported a complete absence of fluid leakage between maxillary sinuses or nasal fossa and oral cavity (score 5), 100% of patients reported a good or complete recovery of phonation (score 4–5), 93% of subjects reported a good or complete recovery of swallowing (score 4–5), and 86% of patients reported a good or total personal satisfaction with the maxillary prosthesis (score 4–5).
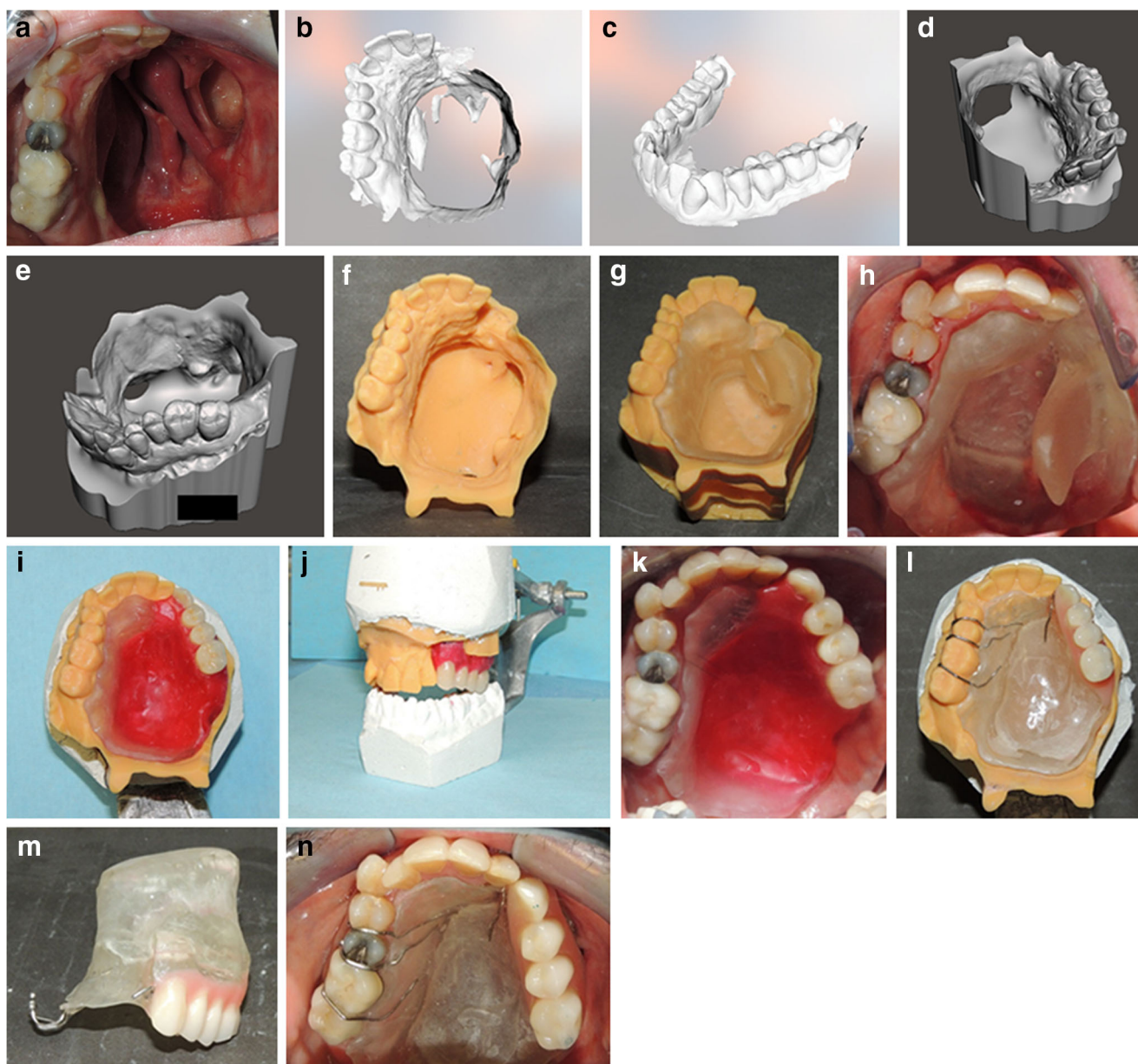
Fig. 1 C.P., male, 41 years. The patient had undergone maxillectomy because of a mucoepidermoid carcinoma of the palate. **a** Intraoral view of postoperative defect 5 months after surgery; **b**, **c** digital images of the maxillary arch and palate, the maxillary/palatal defect, and the mandibular arch, thanks to scanning by an intraoral optical scanner; **d**, **e** 3D digital cast of the maxilla including the maxillary defect; **f** physical resin cast produced by rapid prototyping from digital casts; **g–n** based on the resin casts, maxillary prosthesis was fabricated through conventional methods and steps

Discussion

A good support, stability, and sufficient retention for maxillofacial prostheses are crucial for an appropriate functioning of a maxillary prosthesis. When major anatomic structures have been ablated or completely altered following a tumor removal, a good functioning of maxillary prosthesis is even more challenging [1–8].

CAD-CAM technology and digital fabrication methods may help to determine the ideal path of insertion with desired undercuts and good adaptation of the denture base to the supporting tissues in order to enhance the stability and retention of the obturator [3–8].

Of course, the accurate capture of the anatomic morphology of oronasal communications that result in deep cavities and many undercuts may reveal to be difficult with older optical scanners. In fact, in the literature, CT and an intraoral scanner have been combined to overcome these problems, and the 3D image of the maxillary defect was generated to form the basic step for the digital prosthetic process. Digital impressions have been used successfully and widely in the field of fixed dentures [2–8].
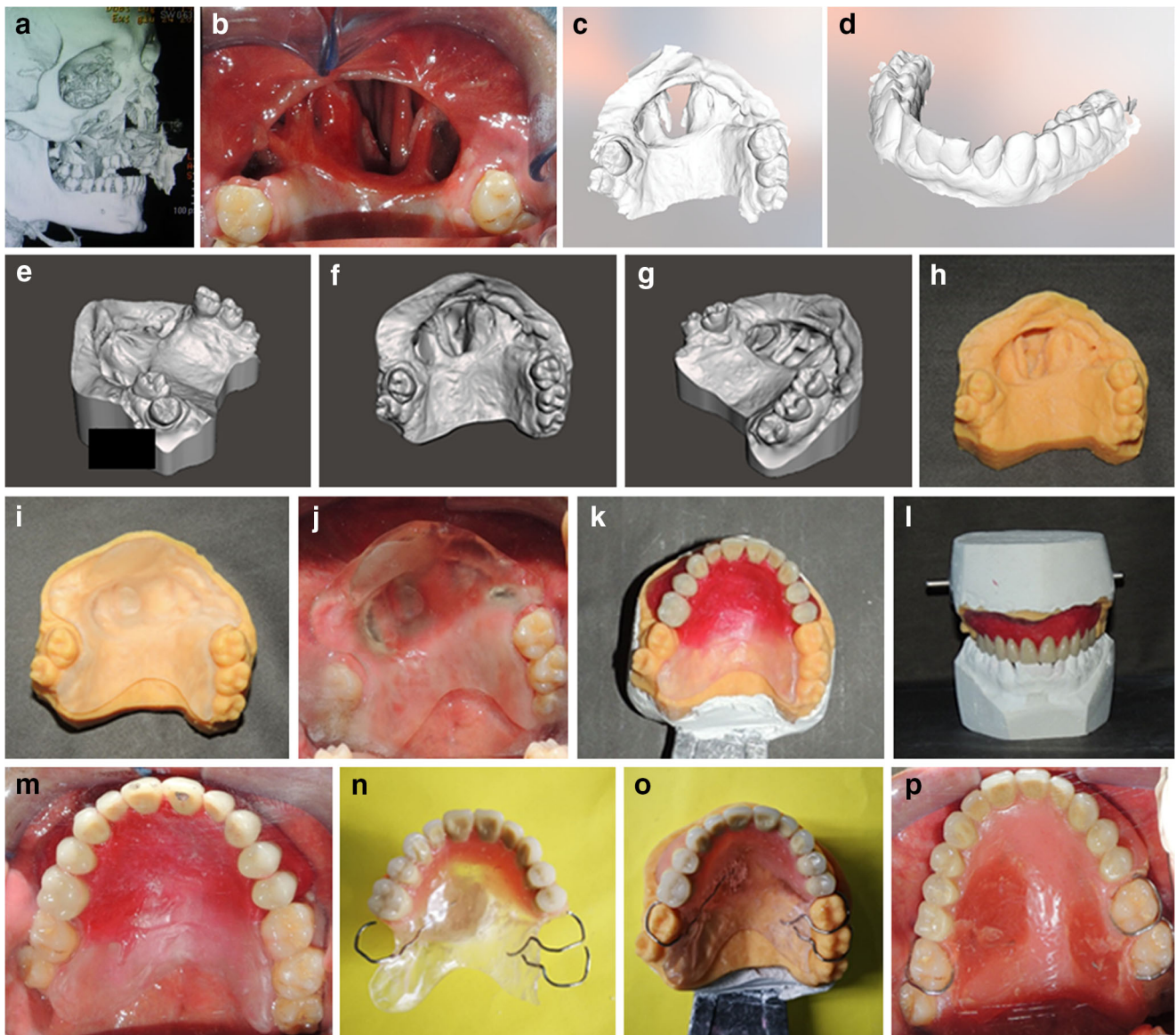
Fig. 2 A.V., male, 31 years. The patient had undergone the traumatic avulsion of the maxilla because of a motor vehicle accident. **a** Preoperative CT scan showing the traumatic avulsion of the maxilla; **b** intraoral view of postoperative defect 5 months after surgery; **c, d** digital images of the maxillary arch and palate, the maxillary/palatal defect, and the mandibular arch, thanks to scanning by an intraoral optical scanner; **e–g** 3D digital cast of the maxilla including the maxillary defect; **h** physical resin cast produced by rapid prototyping from digital casts; **i–p** based on the resin casts, maxillary prosthesis was fabricated through conventional methods and steps

In the present study, the Trios 3Shape (Copenhagen, Denmark) optical scanner was used as an intraoral digital impression system. This system works under the principle of ultrafast optical sectioning and confocal microscopy. The system can create a final digital 3D model instantly to reflect the real configuration of teeth and gingival color. The Trios intraoral scanner is a powder-free device in the scanning process [1–5].

Compared to a conventional impression, intraoral digital scanning can save time and steps for maxillofacial surgeons, dentists, and technicians. At the dental office tray selection, material dispensing, material setting, material disinfection, and impression packaging and shipping are avoided, whereas at the lab plaster, pouring, die cutting, trimming, articulation, and extraoral scanning are no longer necessary [1–8].

Of course, the use of a digital workflow in maxillary obturator prosthesis fabrication has some further significant and potential benefits: the avoidance of the risk of aspiration while the impression is being made, the overcome of the difficulties associated with whole tissue undercut impression, and the possibility of performing an adequate digital impression in spite of the reduced mouth opening after scar contracture or radiotherapy. Patients who have a tendency to gag during impression procedures, as well as those with special needs

Table 1 Pathologies of patients within the study population

Pathology		N
Malignant tumors		
	Squamocellular carcinoma	10
	Adenoid cystic carcinoma	5
	Adenocarcinoma	3
	Mucoepidermoid carcinoma	2
	Verrucous carcinoma	1
	Melanoma	1
	Inverted papilloma	1
MRONJ		2
Artero-venous malformation		1
Pleomorphic adenoma		1
Traumatic maxillary avulsion		1

or anxiety, may tolerate the intraoral scanning procedure better than a conventional impression [1–6].

There are further features to be considered: digital scanning can capture the tissues in a passive state, thereby developing a mucostatic impression; communication between the dental laboratory and dental office can be improved through the use of screenshots; and designs can be approved and modified before the framework is fabricated. Patients who have allergies to impression materials could also benefit from this technology [1–8].

However, overhead costs related to initial hardware and software investments for commercial laboratories have to be considered.

The maxillofacial prosthetist was actively involved in the multidisciplinary process of diagnosis and clinical decision making, in agreement with Kreeft et al. [1–8].

Of course, a close monitoring of the patient during long-term follow-up is essential both as for the malignant pathology and the stability of maxillary obturator prosthesis.

Surgical free flap reconstruction remains a valid alternative to obturator prosthesis, although it is still associated with

increased operation time, opportunity for failure, and possible donor site morbidity. In contrast, as aforementioned, fabrication of an obturator prosthesis shortens the operation time and offers the possibility of immediate and adequate dental rehabilitation, allowing the examination of the maxillectomy defect during oncological follow-up [1–8].

In conclusion, digital technology for the fabrication of maxillary obturator prosthesis may be effective and useful. The reduced laboratory working time, the avoidance of the risk of aspiration of impression materials, the overcome of the difficulties associated with whole tissue undercut impression, and the possibility of performing an adequate digital impression in spite of the reduced mouth opening after scar contracture or radiotherapy are just some of the most important advantages that have been encountered thanks to this promising technology.

Compliance with ethical standards

Conflict of interest The authors have no financial interest to declare in relation to the content of this article.

Table 2 subjective outcome within the study population (score 1—worst result; score 5—best result)

	Score 1 (n)	Score 2 (n)	Score 3 (n)	Score 4 (n)	Score 5 (n)
Absence of fluid leakage between maxillary Sinuses or nasal fossa and oral cavity	0	0	2	0	26
Recovery of phonation	0	0	0	8	20
Recovery of swallowing	0	1	1	5	21
Personal satisfaction of the patient with the maxillary prosthesis	0	1	3	6	18

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