

# Evaluation of discriminative sensibility recovery in patients with buccinator myomucosal flap oral cavity reconstructions

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## Abstract

**Background** Sensitive restoration is the primary aim of oral reconstructive surgery. Discriminative sensibility is an important index of innervation density of a tissue. Instruments normally used to assess this type of skin sensibility are bulky and difficult to introduce in the oral cavity, even in healthy patients with a normal mouth opening. This study was intended to evaluate the recovery of static and dynamic two-point discrimination sensitivity of the reconstructed areas of the oral cavity.

**Methods** Surgical staples, calibrated in predetermined width (from 1 to 30 mm) and introduced in the oral cavity with a Mayo needle holder, were used to evaluate two-point discrimination recovery in 57 patients who underwent reconstructive surgery with buccinator myomucosal flaps. Tests were conducted both on the reconstructive flap and on the non-operated contralateral side. The latter also included the non-operated cheek.

**Results** All of the considered flaps showed a recovery of tactile sensitivity. The overall average discriminative threshold value assessed on this sample was  $9.11 \pm 2.46$  mm for the static and  $6.56 \pm 2.46$  mm for the dynamic.

**Conclusions** The use of surgical staples allows easy assessment of tactile sensitivity in all oral cavity areas, even in operated patients who often present lockjaw or microstomia. In our series, buccinator myomucosal flaps demonstrate a much greater recovery of the sensation compared to results found in the literature on fasciocutaneous free flaps, even those reinnervated.

Level of Evidence: Level III, prognostic study

**Keywords** Discriminative sensitivity · Sensitivity assessment · Oral cavity reconstruction · Buccinator myomucosal flap · Cheek myomucosal flap

## Introduction

Sensitive restoration is the primary aim of the reconstructive surgery in post-traumatic or post-ablative defects of the oral cavity [1]. Mucosal sensitivity plays a key role in functions such as chewing, swallowing, and speech which impairment strongly affects the patient's quality of life (QoL) [2–7]. To address this task, the use of reinnervated free flaps has an increasing trend since the 1990s [8]. Therefore, it is essential to assess the presence of tactile sensitivity, testing its various domains such discriminative sensibility, to evaluate the outcome of reconstructive techniques. Two-point discrimination is an index of discriminative sensibility that includes also stereognosis, graphesthesia, and topognosis and can be considered a density of innervation index. Actually, there are several tools used to assess oral cavity two-point discrimination [8–14].

However, these tests are routinely used for the evaluation of skin sensitivity, and it can be difficult to introduce the tools

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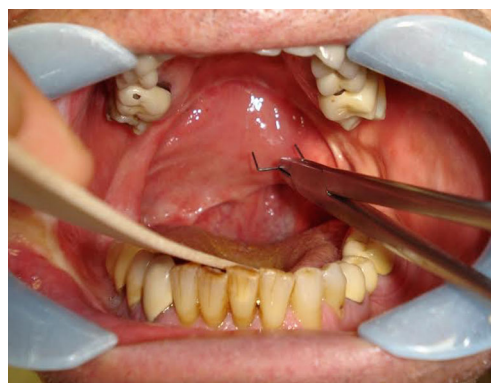
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inside the oral cavity, especially if it is needed to test most posterior areas, and it become even harder or nearly impossible in patients with lockjaw or microstomia. For this reason, we propose a new tool that consists in surgical staples calibrated in predetermined width (from 1 to 30 mm) and introduced in the oral cavity with a Mayo needle holder (Figs. 1 and 2).

In this work, we used this test to evaluate two-point discrimination in 57 patients who underwent reconstructive surgery with buccinator myomucosal flaps. In our knowledge, there are no previous reports of this method employed to evaluate the sensitivity recovery of oral reconstructions. Results have been compared with the literature review data reports on the sensitivity restoration of microvascular fasciocutaneous free flaps.

### Materials and methods

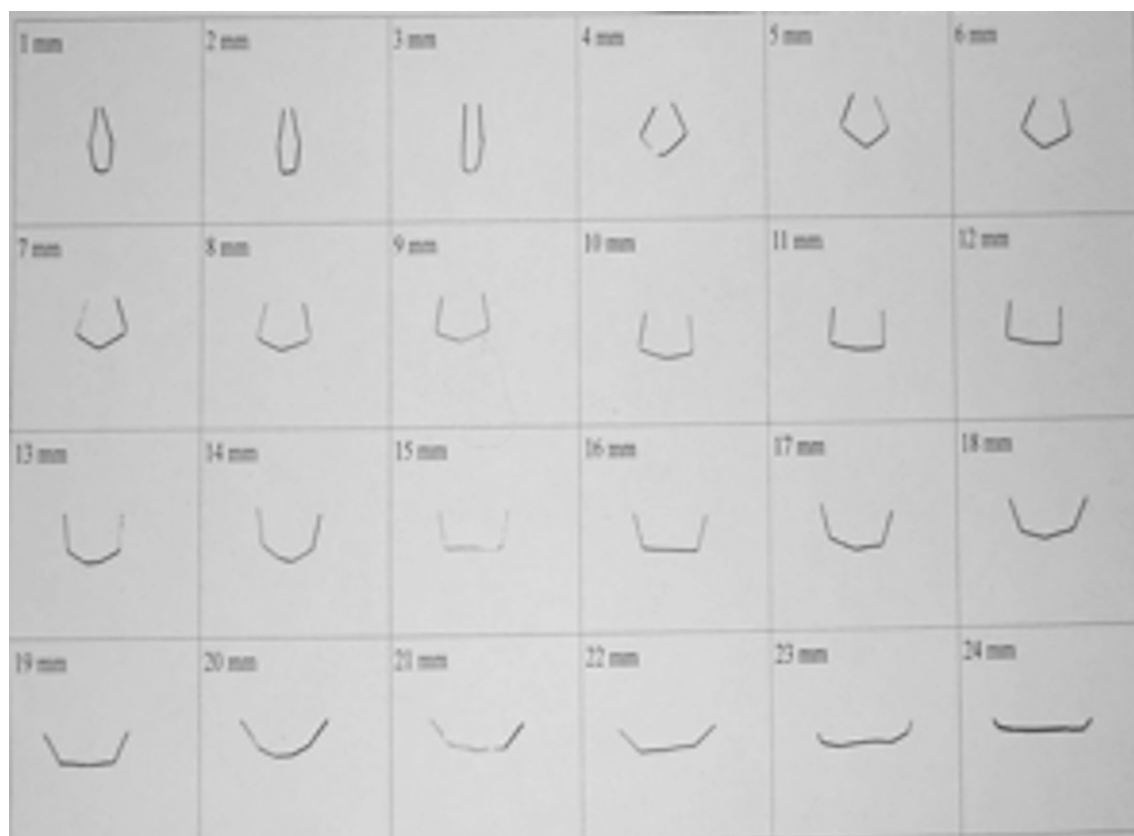
From June 2005 to January 2011, at the Operative Unit of Oral and Maxillofacial Surgery of the University Hospital of Sassari, 69 myomucosal buccinator flaps were



**Fig. 2** Surgical staples introduced in the oral cavity to assess soft palate sensitivity

performed in 66 patients for reconstruction of medium-sized defects (from 2 to 10 cm) involving soft tissues of the oral cavity and oropharynx [15–17]. The sample considered for the study is reported in Tables 1, 2, and 3. Harvesting of the flaps has been performed as described by Massarelli [15] (Fig. 3).

The study was intended to evaluate the two-point discrimination of the reconstructed areas of the oral cavity at a 4-year



**Fig. 1** Surgical staples with different thresholds

minimum follow-up. The tests were conducted both on the reconstructive flap surface and on the non-operated contralateral side. The non-operated cheek was used as a control. In each site, both static and dynamic two-point discriminations, obtained by gently swapping the staple on the mucosa, were evaluated.

All of the patients were blindfolded and examined by a single operator in a quiet room. The staple, starting from the less wide, was lightly pressed on the examined surface, and it was asked to the patient if he felt one or two stimuli. Wider staples were used until the patient did not feel the two-point stimulation. The corresponding threshold was recorded, and the resulting data were analyzed with a proper program (Microsoft Excel, Microsoft Corp., Redmond, WA).

The research protocol was approved by the Ethics Committee of the University of Sassari.

## Results

Of the 66 patients who underwent myomucosal flap reconstruction, 4 died for comorbidity before the tests. One flap was lost due to total necrosis. Four patients did not show up for the test study. These patients were excluded from the evaluation.

The remaining 57 patients (60 flaps) were collected for the study.

All of the considered flaps (100%) showed a recovery of tactile sensitivity.

**Table 1** Etiology of defects

| Etiology                                 | No. of patients |
|--|-----------------|
| Ablative surgery                         | 52              |
| Squamous cell carcinoma                  | 47              |
| T1                                       | 3               |
| T2                                       | 35              |
| T3                                       | 7               |
| T4                                       | 2               |
| Ameloblastoma extraosseous dissemination | 1               |
| Peripheral ossifying fibroma             | 2               |
| Minor salivary gland pleomorphic adenoma | 1               |
| Giant cells granuloma                    | 1               |
| Oro-cervical fistula                     | 3               |
| Oro-nasal fistula                        | 5               |
| Trauma                                   | 3               |
| Grade III osteoradionecrosis of the jaw  | 3               |

**Table 2** Defect's site

| Site                        | No. of patients |
|-----------------------------|-----------------|
| Anterior floor of the mouth | 19              |
| Tongue                      | 11              |
| Hard palate                 | 8               |
| Soft palate                 | 7               |
| Retromolar trigone          | 6               |
| Lateral floor of the mouth  | 6               |
| Maxillary alveolar ridge    | 2               |
| Mandibular alveolar ridge   | 3               |
| Lip                         | 2               |
| Cheek                       | 2               |

Static and dynamic two-point discrimination threshold values, assessed in each oral cavity area, compared with contralateral healthy areas, are shown in Table 4. An assessment of the contralateral healthy side was not possible in patients with midline defects or with defects involving the anterior floor of the mouth or the whole soft palate.

The overall average two-point discrimination threshold was  $9.11 \pm 2.46$  mm for the static and  $6.56 \pm 2.46$  mm for the dynamic. The values found on the non-operated cheek were  $4.4 \pm 1.1$  mm (static) and  $3.2 \pm 1.4$  mm (dynamic). Two-point discrimination on the non-operated cheek was not assessed in three patients, because bilateral myomucosal flaps were performed for reconstruction.

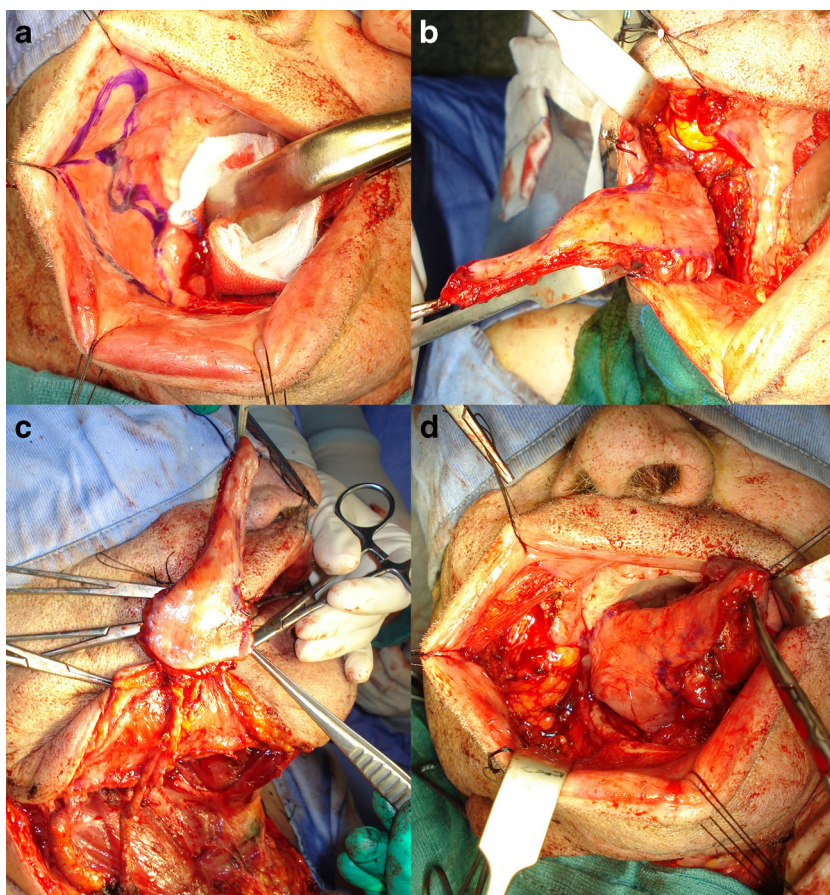
## Discussion

In the era of functional reconstructive surgery, it is quite unacceptable that the success of oral cancer treatment would be just associated with the disease-free survival.

**Table 3** Flap's type according to the Massarelli classification [15]

| Flap                   | No. of patients |
|------------------------|-----------------|
| FAMM <sub>SB</sub>     | 5               |
| FAMM <sub>IB</sub>     | 15              |
| BAMM                   | 5               |
| FAMMIF <sub>IB</sub>   | 7               |
| BAMMIF                 | 12              |
| t-FAMMIF <sub>IB</sub> | 20              |
| a-FAMMIF <sub>IB</sub> | 5               |

**Fig. 3** t-FAMMIF harvesting technique. **a** Defect shape is reported on the cheek mucosa preserving the Stensen duct and oral commissure. **b** The facial artery and vein are isolated, ligated in the distal portion, and then dissected until their origin. **c** The flap is pulled out in the neck through a paramandibular tunnel. **d** The flap is finally taken back inside the oral cavity through the floor of the mouth and then sutured to the recipient site



The steadily increasing long-term survival rate of patients leads to the need to preserve the functionality of the oral cavity in order to ensure QoL as high as possible. Chewing, swallowing, and speech, largely influencing the QoL, are strongly conditioned by oral mucosa sensitivity [2–7]. The restoration of sensitivity must be therefore a

primary goal of reconstruction surgery [1]. In order to obtain a “like with like” reconstruction, myomucosal flaps represent a versatile technique to repair oral cavity mucosal defects [15–17] (Figs. 4, 5, and 6).

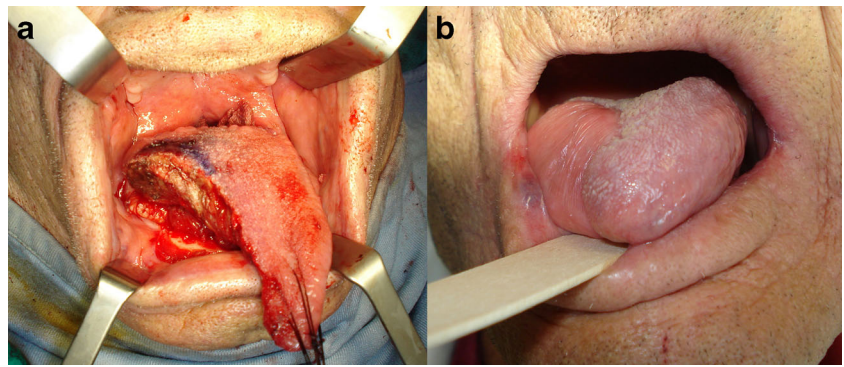
Spatial resolution is the minimum width that two stimuli must have to be discriminated as separated. It is an

**Table 4** Detected discrimination thresholds

| Site                        | No. of patients | Flap static 2-point discrimination (mm) | Flap dynamic 2-point discrimination (mm) | Contralateral static 2-point discrimination (mm) | Contralateral dynamic 2-point discrimination (mm) |
|-----------------------------|-----------------|---|--|--|---|
| Anterior floor of the mouth | 15              | 12 ± 5.4                                | 8.9 ± 4.1                                |  |   |
| Lateral floor of the mouth  | 6               | 11.3 ± 5.9                              | 9.5 ± 5.6                                | 5.2 ± 2.2  | 4.1 ± 1.3   |
| Tongue                      | 9               | 11.5 ± 4.8                              | 8 ± 2.9                                  | 3.4 ± 1.6  | 2.9 ± 0.7   |
| Hard palate                 | 8               | 9.8 ± 3.3                               | 7.6 ± 2.3                                | 4.3 ± 1.9  | 3.5 ± 1.6   |
| Soft palate                 | 6               | 8.1 ± 2.4                               | 5.8 ± 2.3                                | 4.6 ± 2  | 3.7 ± 1.7   |
| Retromolar trigone          | 6               | 10.5 ± 4.7                              | 7.1 ± 2.9                                | 5.3 ± 2.1  | 5 ± 3.3   |
| Mandibular alveolar ridge   | 2               | 5.5 ± 0.7                               | 4 ± 0                                    | 3  | 2.5 ± 0.7   |
| Maxillary alveolar ridge    | 3               | 7.3 ± 3.2                               | 4.6 ± 1.5                                | 4.3 ± 0.5  | 3.5 ± 0.5   |
| Cheek                       | 2               | 6 ± 1.4                                 | 3.5 ± 0.7                                | 3.5 ± 0.7  | 3   |



**Fig. 4** Hemiglossectomy following squamocellular carcinoma (a) reconstructed with t-FAMMIF (b)



index of discriminative sensibility that includes also stereognosis, graphesthesia, and topognosis. Two-point discrimination threshold is determined by innervation density (afferent fibers per square centimeter). For this reason, it can be considered the finest sensitivity than the tactile that is only due to the presence of a receptive field supported by a nervous sensitivity unit. Static and dynamic two-point discriminations have been evaluated in this work. The static test evaluates the density of nervous fibers connected to slow adaptation receptors (Merkel corpuscles). On the contrary, the dynamic test assesses the innervation density of the rapid adaptation receptor system (Pacinian and Meissner's corpuscles) [18]. For this reason, discriminative sensibility can be considered as a quantitative index of flap reinnervation.

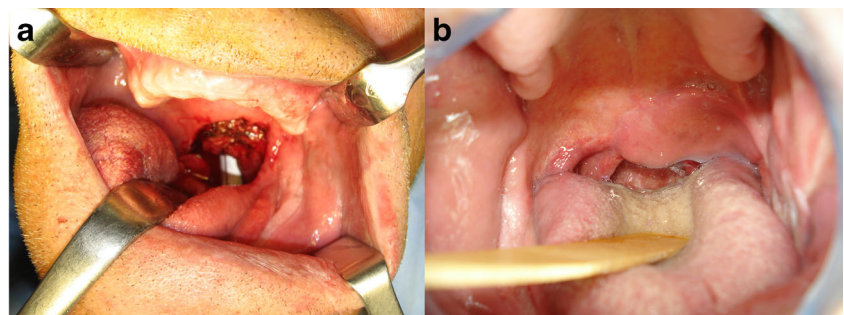
Currently, there are several tools to assess two-point discrimination. The MacKinnon-Dellon Disk-Criminator © is a disk with seven pairs of tips placed at different widths. It has been used in several works [9, 10] due to its simplicity, accuracy, and low cost. However, the bulky shape of the tool allows only the assessment of the lips, the alveolar ridges, and the tip of the tongue while it is impossible to reach the most posterior areas of the oral cavity. Even the pressure-specific sensory device (PSSD) can be used to determine the discriminatory spatial thresh-

old [11]. This method is very accurate, and the tool can be easily introduced into the oral cavity. On the other hand, the cost of the instrument is very high. Other tools such as compass or nautical gauge have been described, but they are bulky and it is quite impossible to use them inside the oral cavity [12].

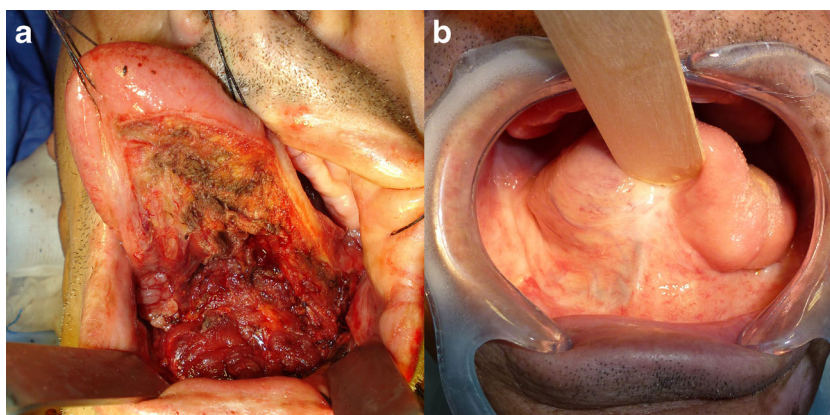
For this reason, in this study, surgical staples set up at different widths (from 1 to 30 mm) have been used. Staples can be sterilized and used multiple times, and they can be easily introduced inside the mouth with a Mayo needle holder, reaching without problems the most posterior areas of the oral cavity even in patients who undergone oncologic surgery, with lockjaw or microstomia. Furthermore, this test is accurate and reliable, and its irrelevant cost allows its large-scale application. In our knowledge, there are no previous reports of the use of this method to evaluate the two-point discriminatory spatial threshold. Moreover, no quantitative studies are reported up today on the sensitivity recovery of the myomucosal flaps.

In our series, all the flaps performed recovered their sensitivity. A review of the literature about the recovery of tactile sensitivity in oral reconstructive surgery with fasciocutaneous free flaps (radial forearm flap and anterolateral thigh flap) shows different reports that can be

**Fig. 5** Left palate and lateral pharyngeal wall defect following squamocellular carcinoma ablation (a) reconstructed with BAMMIF (b)



**Fig. 6** Glosso-pelvectomy and mandibular marginectomy following squamocellular carcinoma (a) reconstructed with FAMMIF (b)



compared with our study. A framework summary is reported in Table 5.

The available data are widely variable [9–14, 19, 20]: it has been demonstrated that reinnervated free flaps have the best functional results. No reinnervated flaps recover sensitivity in 20–100% of cases while reinnervated flaps do it in 60–100%. In our series, the 100% of the flaps performed (100%) has recovered their tactile sensitivity without the necessity of nervous microanastomosis. This may be related to the low fibrotic retraction of the bucci-

nator muscle flaps that favors the nerve sprouting from the surrounding tissues.

With regard to the two-point discrimination, only two works report spatial resolutions to be lower than those detected in our study [21, 22]. In the other works available in the literature, a discriminative sensibility recovery is reported in 16–100% of the patients who undergone oral cavity reconstruction with non-innervated or innervated fasciocutaneous free flaps with average threshold values well greater than 20 mm (Table 5).

**Table 5** Evaluation of two-point discriminative sensibility on reinnervated (I) and non-reinnervated (NI) free flaps

| Authors                | Year | Series     | % of recovery  | Average      |         |
|------------------------|------|------------|--|--------------|---------|
|                        |      |            |  | Static       | Dynamic |
| Boyd et al. [21]       | 1994 | 8 RFFF-I   |  | 3.5          | 2.5     |
| Shindo et al. [23]     | 1995 | 9 RFFF-NI  | 66   | 25–35        | 25–35   |
| Vriens et al. [20]     | 1996 | 40 RFFF-NI | 36   |              |         |
| Lvoff et al. [14]      | 1998 | 38 RFFF-NI | 34% of patients discriminate a 25-mm stimulus  |              |         |
| Kimata et al. [19]     | 1999 | 8 ALT-I    | 87   |              |         |
| Kimata et al. [19]     | 1999 | 6 ALT-NI   | 16   | 30           | 20      |
| Santamaria et al. [22] | 1999 | 28 RFFF-I  |  | 4.5          |         |
| Kuriakose et al. [9]   | 2001 | 17 RFFF-I  | 100  | 12           | 8       |
| Kerawala et al. [24]   | 2006 | 38 RFFF-NI | 60   | 18.9 (10–24) |         |
| Avery et al. [25]      | 2006 | 40 RFFF-NI | 34% of patients discriminate <20-mm stimulus   |              |         |
| Kim et al. [26]        | 2008 | 12 RFFF-NI |  | 22.6         |         |
| Kim et al. [26]        | 2008 | 5 RFFF-I   |  | 13.5         |         |
| Loewen et al. [13]     | 2010 | 8 RFFF-I   | 34% of the patients discriminate a 3-mm stimulus on the tip of the tongue or a 6-mm stimulus on the lateral margin |              |         |

## Conclusion

Evaluating the sensitivity recovery of the oral reconstructive flaps, it is crucial to rate the quality of the reconstruction itself. The assessment of tactile sensitivity can be difficult because of the limits of the tools that are commonly used. That matter can be overcome using surgical staples set up at different widths that can be easily introduced inside the oral cavity, testing also the most posterior areas even in patients with a limited mouth opening. With this tool, we evaluated 57 buccinator myomucosal flaps, finding a sensitive recovery and a discriminative threshold higher than these reported on fasciocutaneous free flaps, even if reinnervated.

For this reason, we first consider myomucosal flaps to reconstruct the small- to medium-sized soft tissue defects of the oral cavity. These flaps allow a better tissue-like reconstruction with greater sensitive recovery that is crucial for good oral function and better quality of life.

## Compliance with ethical standards

**Conflict of interest** Luigi Angelo Vaira, Olindo Massarelli, Roberta Gobbi, Damiano Soma, Giovanni Dell'aversana Orabona, Pasquale Piombino and Giacomo De Riu declare that they have no conflict of interest.

**Patient consent** Patients provided written consent before their inclusion in this study. Additional consent was obtained for the use of their images.

**Funding** No funding sources were necessary for this study.

**Ethical approval** This study was approved by the Ethics Committee of the University of Sassari and therefore performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments.

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