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Original article

Radial forearm flap versus antero-lateral thigh flap in oral soft tissue reconstruction: Update and statistical analysis on our 77 consecutive cases for an objective selection criteria

Caterina Marra[1], *Valentina Pinto*[1], *Elisa Benanti*[2], *Federico De Maria*[1], *Massimo Pinelli*[1], *Antonio Spaggiari*[1], *Giorgio De Santis*[1]

[1]Department of Plastic and Reconstructive Surgery, Policlinico of Modena, University of Modena and Reggio Emilia, Modena, Italy; [2]Plastic and Reconstructive Surgery, Istituto Clinico Città Studi ICCS, Milano, Italy

Abstract. *Background and aim:* The radial forearm free flap (RFF*f*) and the antero-lateral thigh flap (ALT*f*) are considered the "key flaps" for oral cavity reconstruction. Nowadays, the literature lacks of an objective and standardized decision-making algorithm for the flap choice. The aim of this study is to describe a decision-making algorithm concerning the more appropriate flap, RFF*f* or ALT*f*, in the reconstruction of intra-oral soft tissues based on the volumetric analysis of the defect with a pre-operative Magnetic Resonance Imaging (MRI), updating our previous surgical experience. *Methods:* We conducted a retrospective observational study including 77 patients who underwent microsurgical reconstruction with RFF*f* or ALT*f* after tumor resection of the soft tissues in the oral cavity. During follow-up, patients were evaluated using the UW-QOL questionnaire. *Results:* Analyzing the scores of the UW-QOL questionnaire based on the size of the tumor on preoperative MRI we found that for tumor volume <50cc and between 50-70cc, the patients reconstructed with RFF*f* obtained statistically significant better scores compared to the ALT*f* group, while for tumor volume >70cc, the patients reconstructed with ALT*f* reported statistically significant better scores. *Conclusions*: Pre-operative RMI-guided volumetric assessment of oral cancer plays a key role in the planning of adequate soft tissue reconstruction and can objectively help surgeons in the correct choice of the flap (RFF*f* vs. ALT*f*) for each case based on preoperative tumor size, suggesting for defects <50cc and between 50 and 70 cc a reconstruction with RFF*f*, while for defects >70cc a reconstruction with ALT*f*. (www.actabiomedica.it)

Key words: oral cavity algorithm reconstruction, radial forearm flap, antero-lateral thigh flap, MRI assessment, soft tissue reconstruction

Introduction

Extensive surgical resection after tumor excision can result in a large and complex defect of the oral cavity, representing a significant reconstructive challenge for the plastic surgeon, developing esthetic deformity and impairment of functionality, involving mastication, deglutition, and speech (1).

Microsurgery is nowadays the gold standard for head and neck reconstruction, permitting to restoration of the anatomy maintaining the proper integrity of the aerodigestive tract, and allowing vital functions, such as chewing, swallowing, speech, and facial expression.

Although several free flaps are available for head and neck reconstruction (latissimus dorsi, rectus abdominis, jejunum, medial sural artery perforator flap, superficial circumflex iliac artery perforator flap, etc. (2–6)), the radial forearm free flap (RFF*f*) and the antero-lateral thigh flap (ALT*f*) are considered the "key flaps" for oral cavity reconstruction (2,7–10).

The radial forearm flap (RFF*f*) was first described by Yang in 1981 (11) as a thin and pliable flap potentially useful to reconstruct any soft tissue defect. Constant anatomy makes easy the flap harvesting. Furthermore, the long vascular pedicle and the large diameter of radial vessels allow reliable anastomosis. In selected cases, it can be harvested also as a sensate flap. Thanks to its easy tailoring in different sizes and shapes, radial forearm flap (RFF*f*) quickly gained popularity for intra-oral reconstruction (12,13). Donor site morbidity is the main disadvantage, requiring an anesthetic skin graft for forearm closure (11,14).

Anterolateral thigh flap (ALT*f*) was first described in 1984 by Song. The popularity of this fasciocutaneous flap increased in the 2000s when Wei et al. described in detail the intramuscular perforator dissection technique (9,10,15). The versatility of the ALT*f* is exceptional. A large quantity of soft tissue can be harvested from the thigh without much morbidity. The flap can be harvested as fasciocutaneous, cutaneous, myocutaneous, and muscle and can be sensate (10). The main advantages of this flap are a long and wide vascular pedicle and the possibility to tailor it in different tridimensional shapes, according to the defect, combined with a low donor site morbidity (9). Disadvantages are the anatomical vascular variability with a more laborious and prolonged dissection (14) and a slower learning curve for young surgeons. Furthermore, this flap can be bulky with a thicker skin and a thicker fat layer that needs to be managed (16) and it may respond to folding with venous congestion (17).

Although ALT*f* and RFF*f* are overall considered the gold standard for oral cavity reconstruction, and several studies evaluate and compare the ALT*f* and RFF*f* (7,14,18–21), the literature lacks an objective and standardized decision-making algorithm in the flap choice (22,23). To date, soft tissue reconstruction of the oral cavity is performed according to defect's size, patient's features as well as surgeon's experience.

The aim of this study is to validate our previous proposal (24) of a clear and objective decision-making algorithm concerning the flap, ALT*f* and RFF*f*, more appropriate in the reconstruction of intra-oral soft tissues based on the pre-operative MRI (magnetic resonance imaging) volumetric analysis of the defect.

Materials and methods

In this retrospective observational study, we updated our case series reaching 77 patients, referred to Modena University Hospital in the period from January 2014 to May 2022. Patients enrolled underwent surgical resection for soft tissue oral cavity cancer, ipsilateral or bilateral neck dissection, and contextual microvascular reconstruction with radial forearm flap RFF*f* or antero-lateral tight flap ALT*f*.

To reduce bias of different quality and standard of the radiological images, only patients who underwent pre-operative MRI in our Hospital were enrolled in the study. Other inclusive criteria were: BMI (BMI) between 18 and 30 kg/m, absence of metastasis, and adequate patient compliance.

Patients with severe comorbidities and ASA>3 according to the American Society of Anesthesiologists score, patients undergoing total glossectomy and with previous radiation therapy, were excluded from the study.

Volumetric assessment of the tumor on pre-operative 3,5T MRI (size evaluation), topographic evaluation based on the localization of the tumor in the oral cavity regions, and type of microsurgical reconstruction (ALT*f* or RFF*f* used for the reconstruction) were evaluated in our analyses.

In agreement with the radiologist, we used a geometric principle to evaluate the volume of the tumor in cubic centimeters (cc), by using the formula *base x height x depth* reported at the MRI imaging. Patients were divided into three groups: Group A with a volume < 50cc, Group B with a volume between 50-70 cc, and Group C with a volume >70cc.

Further, the patients were divided into three sets based on tumor localization: *Anterior set (AS), Central set (CS),* and *Posterior set (PS). AS is considered* if the cancer was in the floor, *CS* when the tongue was involved, and *PS* if the tumor developed in the soft palate and in the tonsillar region. For extensive cancers involving a wide area, the location of the cancer, we considered the site most affected by the tumor mass.

Then, we consider for these patients the type of microvascular reconstruction: RFF*f* group and ALT*f* group.

A post-operative QoL questionnaire was administered to the patients included in the study. The University of Washington Quality of Life Questionnaire (UW-QOL) v4 was proposed, through a telephone call during the Covid pandemic. The UW-QoL is a valid, reliable, and responsive questionnaire that allows to measure the QOL for patients with oral cancers. (25) The current version (v 4) consists of 12 disease-specific questions and 3 general items as shown in

Table 1. The investigated topics are pain, appearance, activity, recreation, swallowing, chewing, speech, shoulder, taste, saliva, mood, and anxiety (26,27).

Data collected were submitted to statistical analyses to assess the relationship between surgical technique, tumor volume, and UW-QoL questionnaire score. Statistical evaluation was performed using JMP software for Mac (SAS Institute srl, Milano, Italy). Statistical significance was determined by a p-value ≤0.05.

Written consent was obtained from all patients, and the guidelines of the Declaration of Helsinki were followed.

Results

Between 2014 and 2022, 77 soft tissue microvascular reconstructions of the oral cavity were performed at our Department. Patients enrolled consisted of 44 males and 33 females; the mean age was 60.33 years ± 12.9 years, ranging from 25 to 81 years. Demographic data are shown in Table 2.

An average of 22 months of follow-up was reported, ranging from a minimum of 9 months to a maximum of 38 months.

About topographic assessment, *Anterior set (AS)* with cancer involving the oral floor, was reported in 31.2% of the cases (*n*=24). *Central set* (*CS*) and tongue involvement were reported in 36.4% (*n* = 28). In 32.4% of the treated patients, cancer developed in the *Posterior Set (PS)* with soft palate and/or tonsillar region implication (*n*= 25). Regarding volumetric evaluation detected on the pre-operative MRI, forty-one cases (*n* = 41 – 53.2%), were enrolled in group A (tumor volume <50cc), ten patients (*n*= 10 - 13%) were included in group B (tumor volume between 50cc and 70cc) and twenty-six (*n* = 26 – 33.8%) in the group C (tumor volume >70cc). Figure 1 reported data collected.

According to the type of reconstructive procedure, the RFF*f* group was performed in 48% of the cases (*n*= 37) (Figure 2), while in the ALT*f* group, we included 52% of the treated patients (*n*= 40) (Figure 3).

Squamous Cell Carcinoma was reported in all the cases.

In the QoL investigation, the patients with tumors located in the tongue obtained the worst scores. Data reported, anyway, don't present significant differences compared to patients with tumors located in the anterior (AS) and posterior regions (PS) of the oral cavity (p-value>0.01).

Overall, patients enrolled in group C (with a volume tumor >70 cc at the preoperative MRI scan) reported worse results in the questionnaire than patients of group A and group B, but without statistically significant differences (p-value >0.01). In detail, analyzing the single items, speech reported the worst score for patients with cancer located in the Central Set (CS group), chewing for patients with cancer located in the Anterior Set (AS group), and swallowing for tumors developed in the posterior set (PS group).

All the investigated patients presented higher scores about pain and shoulder involvement items.

Data reported were submitted to statistical analyses, comparing patients reconstructed with the RFF*f* and ALT*f*.

Regardless of tumor size, we did not find a significant difference between patients reconstructed with fasciocutaneous RFF*f* and ALT*f* for anterior region tumors (AS), involving the oral floor (p-value>0.05). In the case of central involvement (CS), when the cancer was located in the tongue, patients reconstructed with RFF*f* obtained better questionnaire scores than patients reconstructed ALT*f* with statistically significant differences, reporting a (p-value =0,011). A statistically significant difference was reported also in the group of patients affected by cancer of the soft palate and tonsillar region. In this group, (PS), patients underwent reconstruction by RFF*f* obtained better results at the QoL scores compared to patients reconstructed with fasciocutaneous ALT*f*, reporting a p-value of 0,00003.

Table 1. University of Washington Quality of Life Questionnaire. Version 4.

1. Pain	I have no pain. There is mild pain not needing medication. I have moderate pain - requires regular medication (e.g. paracetamol). I have severe pain controlled only by prescription medicine (e.g. morphine). I have severe pain, not controlled by medication.	100 75 50 25 0
2. Appearance	There is no change in my appearance. The change in my appearance is minor. My appearance bothers me but I remain active. I feel significantly disfigured and limit my activities due to my appearance. I cannot be with people due to my appearance.	100 75 50 25 0
3. Activity	I am as active as I have ever been. There are times when I can't keep up my old pace, but not often. I am often tired and have slowed down my activities although I still get out. I don't go out because I don't have the strength. I am usually in bed or chair and don't leave home.	100 75 50 25 0
4. Recreation	There are no limitations to recreation at home or away from home. There are a few things I can't do but I still get out and enjoy life. There are many times when I wish I could get out more, but I'm not up to it. There are severe limitations to what I can do, mostly I stay at home and watch TV. I can't do anything enjoyable.	100 75 50 25 0
5. Swallowing	I can swallow as well as ever. I cannot swallow certain solid foods. I can only swallow liquid food. I cannot swallow because it "goes down the wrong way" and chokes me.	100 70 30 0
6. Chewing	I can chew as well as ever. I can eat soft solids but cannot chew some foods. I cannot even chew soft solids.	100 50 0
7. Speech	My speech is the same as always. I have difficulty saying some words but I can be understood over the phone. Only my family and friends can understand me. I cannot be understood.	100 70 30 0
8. Shoulder	I have no problem with my shoulder. My shoulder is stiff but it has not affected my activity or strength. Pain or weakness in my shoulder has caused me to change my work/hobbies. I cannot work or do my hobbies due to problems with my shoulder.	100 70 30 0
9. Taste	I can taste food normally. I can taste most foods normally. I can taste some foods. I cannot taste any foods.	100 70 30 0
10. Saliva	My saliva is of normal consistency. I have less saliva than normal, but it is enough. I have too little saliva. I have no saliva.	100 70 30 0
11. Mood	My mood is excellent and unaffected by my cancer. My mood is generally good and only occasionally affected by my cancer. I am neither in a good mood nor depressed about my cancer. I am somewhat depressed about my cancer. I am extremely depressed about my cancer.	100 75 50 25 0
12. Anxiety	I am not anxious about my cancer. I am a little anxious about my cancer. I am anxious about my cancer. I am very anxious about my cancer.	100 50 0

Which issues have been the most important to you during the past 7 days? Tick **up to 3 boxes**.	Taste Saliva Mood Anxiety Pain Appearance Activity Recreation Swallowing Chewing Speech Shoulder	
GENERAL QUESTIONS		
Compared to the month before you developed cancer, how would you rate your health-related quality of life?	Much better Somewhat better About the same Somewhat worse Much worse	100 75 50 25 0
In general, would you say your **health-related quality of life** during the past 7 days has been:	Outstanding Very good Good Fair Poor Very poor	100 80 60 40 20 0
Overall quality of life includes not only physical and mental health, but also many other factors, such as family, friends, spirituality, or personal leisure activities that are important to your enjoyment of life. Considering everything in your life that contributes to your personal well-being, rate your **overall quality of life** during the past 7 days.	Outstanding Very good Good Fair Poor Very poor	100 80 60 40 20 0

Table 2. Demographic data.

	RFF	***ALT***
Gender, n		
Male	23	21
Female	17	16
Age, years		
Mean (range)	59.92 (25-73)	62.33 (34-81)

Analyzing the scores of the QoL questionnaire based on the size of the tumor on preoperative MRI we found that in groups A and B (volume <50cc and between 50-70cc) the patients reconstructed with RFF*f* obtained better scores with statistically significant differences compared to the ALT*f* group (p-value <0,0001 and p-value =0,0045, respectively), while in group C (volume>70cc) the patients reconstructed with ALT*f* reported better scores to the questionnaire, with statistically significant results (p-value =0,0028) (Figure 4).

Discussion

Microsurgery is nowadays the gold standard for head and neck reconstruction (3), but extensive surgical resections after tumor excision can result in a large and complex defect of the oral cavity, representing a significant reconstructive challenge for the plastic surgeon.

Oral cavity reconstruction is a topic born in 1664 when Marchetti performed the first asportation of tongue carcinoma in Padua and in the mid-1800s when Billroth and von Langenbeck described the first extensive resections of the tongue (28). The first reconstructive approaches were primary or secondary closures, becoming local and loco-regional flaps in the

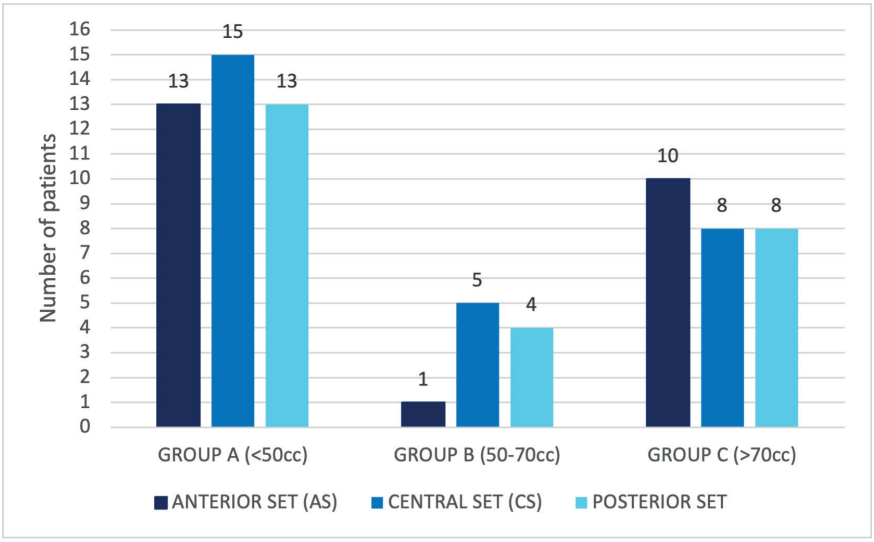

Figure 1. Volumetric and topographic assessment: Number of patients according to tumor localization and size.

Figure 2. Clinical case 1: 52-year-old woman with an SCC G2 of the right margin of the tongue, stage IVa of TNM system. After hemiglossectomy, a tongue reconstruction with an RFFf and a bilateral laterocervical lymph node dissection was performed. A) Preoperative 3.5T RMI - the tumor volume was calculated (25.8 cc). B) Preoperative view of the SCC involving the right margin of the tongue. C) Postoperative photograph - 11 months follow-up after tongue reconstruction with RFFf.

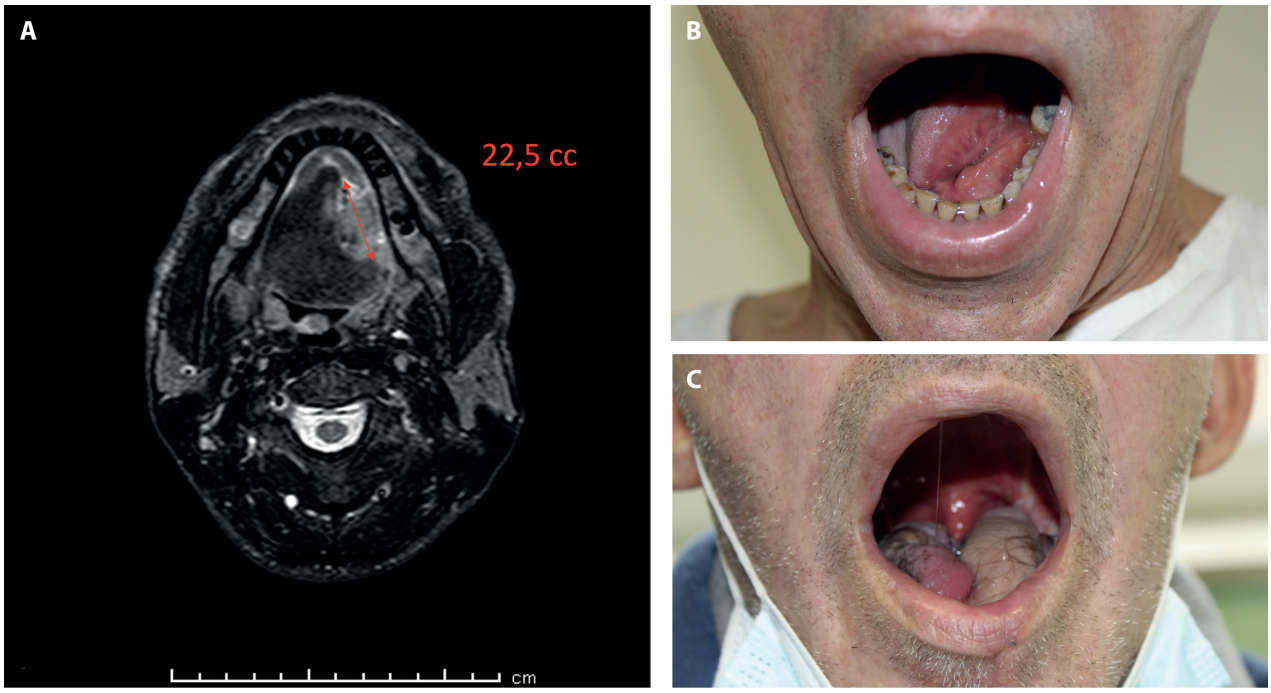

Figure 3. Clinical case 2: 49-year-old smoker man with an SCC of the left oral floor invading the left margin of the tongue, stage IV of TNM system. After the tumor resection, reconstruction with an ALTf and a left laterocervical lymph node dissection was performed. A) Preoperative 3.5T RMI - the tumor volume was calculated (22.5 cc). B) Preoperative views of the SCC involving the left oral floor and left margin of the tongue. C) Postoperative photograph - 9 months follow-up after oral floor reconstruction with ALTf.

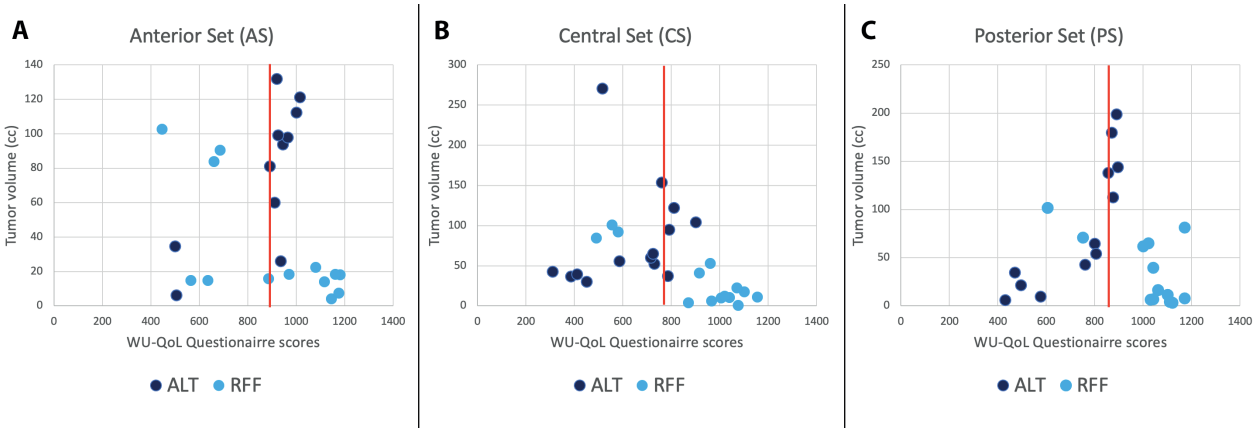

Figure 4. Distribution of patients according to tumor volume and WU-QoL questionnaire score. A) Patients with tumor in the floor (AS). The average of WU-QoL questionnaire score in this group was 883,75 ± 235,3. One patient reconstructed with RFFf and two patients reconstructed with ALTf obtained scores much lower than the mean. The tumor volume of the first patient was 102,67 cc, the tumor volumes of the other two were 34,78 cc and 6,3 cc. B) Patients with tumor in the tongue (CS). The average of WU-QoL questionnaire score in this group was 773,92 ± 244,43. Patients with small tumors reconstructed with ALTf and patients with larger tumors reconstructed with RFFf obtained the lowest scores. C) Patients with tumor in the soft palate (PS). The average of WU-QoL questionnaire score in this group was 877,4 ± 223,50. Also in this group, patients with small tumors reconstructed with ALTf and patients with larger tumors reconstructed with RFFf obtained the lowest score. The red line represents the mean of the WU-QoL questionnaire scores.

post-war era, until the free flap was introduced in 1972 by Taylor (29,30).

Nowadays, more recent microsurgical flaps are becoming increasingly more popular: as the Medial Sural Artery Perforator flap (MSAP*f*) with its thin and pliable skin paddle, its long vascular pedicle, and its minor donor-site morbidity (6) and the Superficial Circumflex Iliac Artery Perforator flap (SCIP*f*) with his low donor-site morbidity and adjustable thickness (super thin or bulky) even if with a short pedicle (31).

Despite these new reconstructive possibilities, the radial forearm free flap RFF*f* and the anterolateral thigh flap ALT*f* are considered the "key flaps" for oral cavity reconstruction (32,33). The functional and morphological success of the reconstruction requires surgical expertise and surgical skills with the two different procedures. To date, the choice between RFF*f* or ALT*f* in soft tissue reconstruction of the oral cavity is performed according to the post-surgical defect's size (percentage of the defect area compared to the total anatomical area), the morbidity of the donor site (need for skin grafting and anti-aesthetic outcomes), patient's features as well as surgeon's experience and preference (7,23).

Although the reconstructive procedure is well standardized, nowadays, the literature lacks an objective and standardized decision-making algorithm in the flap choice. According to the literature, the RFF*f* is considered the favorite flap for defects less than 50% of the entire tongue (3), or less than 1/3-1/2 (34), or less than 2/3 (35). For other authors, the ALT*f* is preferable because of its well-investigated low morbidity at the donor site (36): musculoskeletal dysfunction is eight times more frequent in RFF*f* than in ALT*f* and paresthesia is fifty percent more frequent in RFF*f* (37,38).

In this paper, we discuss that RMI-guided volumetric and topographic assessment of oral cancer plays a key role in the planning of adequate soft tissue reconstruction, and can objectively help surgeons in the correct choice of the right flap for each case. We think, a simple decision-making tool, can strongly encourage young surgeons to make a personal and objective choice for reliable oral cavity reconstruction.

About the post-surgical quality of life, several papers in the literature compared functional outcomes obtained with fasciocutaneous RFF*f* or fasciocutaneous ALT*f* in oral cavity reconstruction, by using QoL questionnaires without taking into consideration preoperative volumetric aspects of the tumor. According to Yuan et al., no relevant differences between the 2 types of reconstruction were reported in the UW-QoL questionnaire for each item (39). No significant differences were found by Tarsitano et al., but they reported better results in terms of swallowing for ALT*f* reconstruction in comparison to RFF*f* reconstruction outcomes, while RFF*f* reconstruction presented better results in speech function. Anatomical features of the RFF*f*, its thinness and pliability, probably, provide better speech articulation, while ALT*f* bulging can restore the tongue-palate contact, useful for adequate swallowing outcome (40). Different conclusions from the UW-QoL questionnaire were referred by Zhang et al. (41); they described better outcomes about swallowing, chewing, and speech in oral cavity reconstruction performed by RFF*f*, reporting statistically significant results. Wang et al. did not find a statistically significant difference in the average score among RFF*f* and ALT*f* groups, but they noted a higher score for ALT*f* reconstruction about appearance and a higher score for RFF*f* about swallowing (42). A recent systematic review evaluated the quality of life of *ALTf* and RFF*f* reconstruction studied with the UW-QoL questionnaire, finding no statistically significant difference in functional outcome, except for the taste domain with better scores for RFF*f* patients (23).

In this paper, we present an update of previous surgical experience (24) and a statistical analysis of reported data.

In our case series, no statistical differences were reported about volumetric and topographic aspects, both considering the type of microsurgical reconstruction and without considering this surgical detail. Overall, the worst functional outcomes were reported on the QoL questionnaire in patients who underwent to wide tumor (group C >70 cc), probably because a larger surgical defect needs a more complex reconstruction, causing poor functional results. According to our experience, MRI pre-operative imaging gives us important statistically significant information: accurate and standardized volumetric assessment of the

tumor size, facilitates the choice of the appropriate reconstructive strategy. The RFF*f* represents the fasciocutaneous flap of choice to obtain better functional results in patients with small-size tumors (group A: < 50cc) and medium-size tumors (group B: 50-70cc). The ALT*f* can provide satisfactory outcomes in patients affected by large-size tumors (>70 cc) reporting in these cases better functional results than RFF*f* reconstruction.

The main limitation of our proposal of creating a real algorithm is the presence of several biases. The different anatomical region involved in the surgery undoubtedly influences functional recovery and then the outcomes reported on the QoL questionnaire and its specific items (e.g. the tongue on phonation and taste); further, these aspects can be strongly influenced by adequate post-operative speech therapy and surgeon's experience in the appropriate tailoring of the microsurgical flap. Furthermore, it must be considered that the functional result in oncological surgery is also influenced by RT, neck dissection, and patient's comorbidities and BMI, which are part of further BIAS present and represent a limitation of our study. To limit these biases we excluded patients who underwent RT before surgery and patients with BMI< 18 and >30 kg/m.

Different quality and standards of the radiological images were controlled by enrolling in the study only patients referred to our University Hospital for pre-operative assessment, but reducing in this way also the case series analyzed. Further objective data must be gained to make the proposed algorithm more widely available.

Conclusions

The radial forearm free flap and the antero-lateral thigh flap are considered nowadays the gold standard for soft tissue reconstruction after extensive surgical resection of the oral cavity. Topographic and volumetric assessment, by using MRI, is certainly a useful preoperative tool that makes it easy to choose the most suitable microsurgical flap for soft tissue oral cancer reconstruction, especially for young surgeons in doubtful cases.

According to our decision-making algorithm proposal, as our previous hypothesis, the reconstruction with RFF*f* is indicated for tumors with a volume less than 70cc. In case of tumor volume greater than 70cc, the ALT*f* is preferred.

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Correspondence:
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Caterina Marra, MD
Department of Plastic and Reconstructive Surgery,
Policlinico of Modena, University of Modena
Via del Pozzo, 71, Modena, 41124 Italy
Phone: +393293972759
E-mail: caterinamarra92@gmail.com
Orcid: https://orcid.org/0000-0002-3511-8127