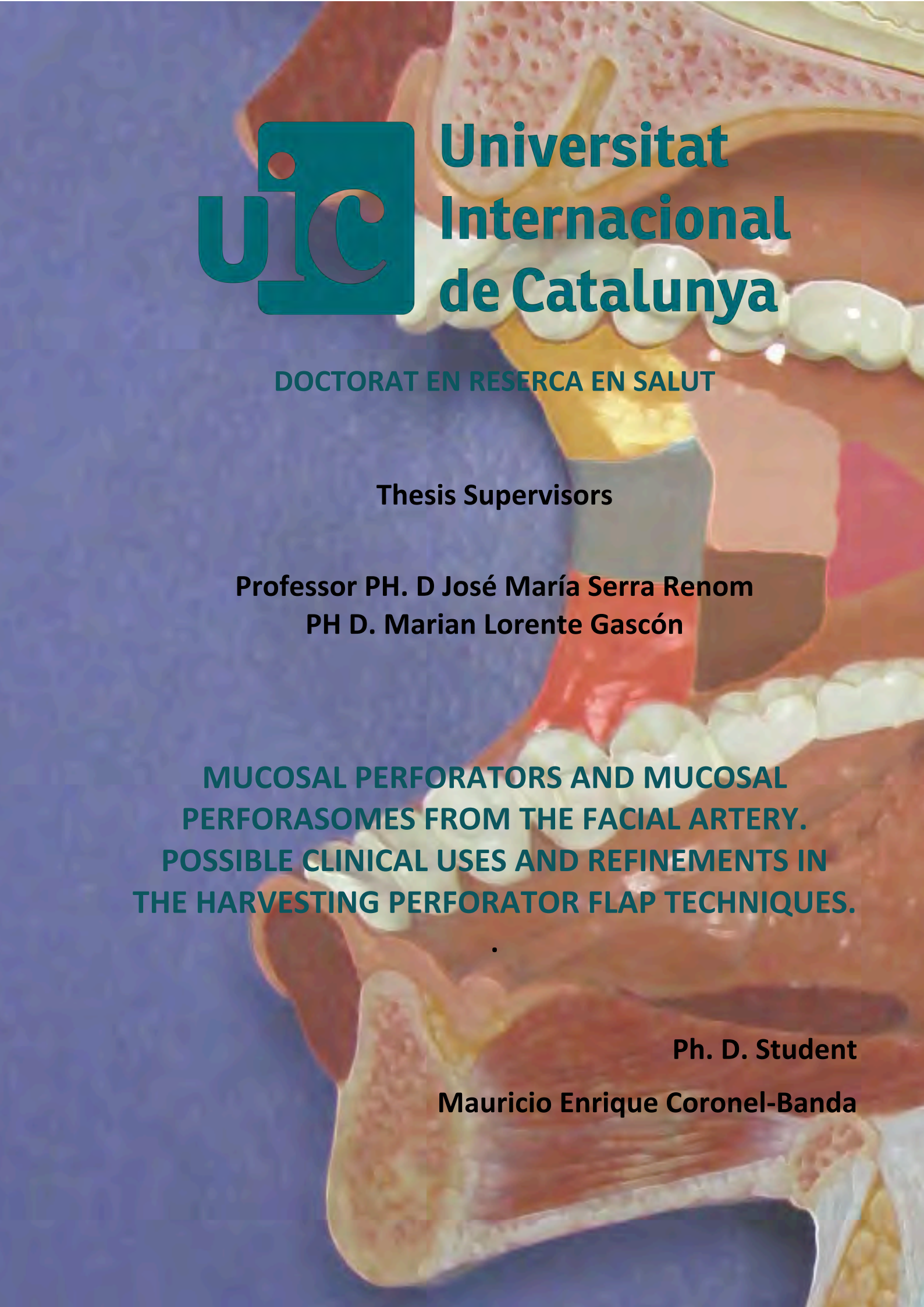
Mucosal perforators and mucosal perforasomes from the facial artery. Posible clinical uses and refinements in the harvesting perfofator flap techniques.

Mauricio Enrique Coronel-Banda



Universitat Internacional de Catalunya

DOCTORAT EN RESERCA EN SALUT

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MUCOSAL PERFORATORS AND MUCOSAL PERFORASOMES FROM THE FACIAL ARTERY. POSSIBLE CLINICAL USES AND REFINEMENTS IN THE HARVESTING PERFORATOR FLAP TECHNIQUES.

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ABSTRACT

BACKGROUND: Neither the oral mucosal perforators of the facial artery nor the mucosal perforasomes they perfused have been described.

Septal perforation is a frequent complication of snorting cocaine. Its reconstruction usually requires complex procedures based on oral mucosa or distant flaps.

METHODS: We studied 30 facial arteries. The first ten were injected with latex, and their diameter and length were measured. All perforators extending from the facial artery and heading directly to the oral mucosa were selected. The remaining twenty arteries were dissected. Perforators larger than 0.5 mm were selected and their diameters were measured; the distance between their exit point over the facial artery and the branching-off point from the superior labial artery was also measured. The selected perforators were injected with 1 cc of diluted ink. Both labial arteries were ligated to limit the study to the mucosal perforators from the facial artery. The results were analyzed statistically. Systematic reviews of PubMed and the Cochrane Library were performed in search of articles describing mucosal perforators or mucosal perforasomes.

We describe a reconstruction of a septal defect caused by cocaine abuse in five patients using a flap based on mucosal perforasomes (MBPF) from the facial artery.

RESULTS: From the specimens with latex, 52 oral mucosal perforators were analyzed. The mean diameter was 0.50 mm and the mean number per facial artery was 5.2. The mean length was 16.42 mm.

Seventy-four perforators from 20 hemifaces were ink-injected; the mean diameter was 0.58 mm, and the mean number per artery was 3.7. The mean area perfused by each perforator was 274.71 sq. mm. Six types of mucosal perforasomes dependent on facial artery perforators were identified.

MBPF obtains satisfactory results in reconstruction once the patient abandons the cocaine habit.

CONCLUSIONS: Most of the mucosal perforators of the facial artery are found between the branching-off points of the inferior and superior labial arteries.

To our knowledge, the concepts of mucosal perforators and mucosal perforasomes have not been described to date. Flaps based on mucosal perforasomes from the facial artery are useful for the reconstruction of septal perforation due to cocaine abuse and may open up promising new areas of research.

INTRODUCTION

In many fields of surgery there are obstacles that interfere with our global vision of a problem, or the state of the art does not allow us to imagine the global picture. We can erroneously assume that something does not exist. In the same way, we could assume that the simple observation of a phenomenon explains all the possibilities. Like Aristotle's assumption that the speed of falling bodies is proportional to their weight, which was later refuted by Galileo (1). In the scientific method we need to demonstrate our hypothesis, as Descartes claims "*Never to accept anything for true which I did not clearly know to be such; that is to say, carefully to avoid precipitancy and prejudice, and to comprise nothing more in my judgment than what was presented to my mind so clearly and distinctly as to exclude all grounds of doubt."* . (2)

Quoting D.H. Lawrence's Lady Chatterley's Lover (3): "What the eye doesn't see and the mind doesn't know, doesn't exist".

The reconstruction of the oral mucosa is an area of interest to facial surgeons, including maxillofacial, plastic, reconstructive and oncologic surgeons. The reconstruction of defects in the oral and nasal cavity presents many challenges to be overcome. We need a soft, pliable and thin tissue to replace the defect caused by various noxious agents. Many diverse solutions have emerged to restore this complex area. Many of them have failed because of lack of similarity on the tissue used to perform a restoration of the defect.

Reconstructive surgery has evolved considerably since the introduction of perforator flaps, (4) which have been described in detail in recent years. (5-8) The

development of perforator flaps allows the performance of single-stage surgery and the extraction of made-to-measure flaps. But until now the interest has focused on the perforators that end on the skin. Even though we suspect of the existence of perforators to the oral mucosa, we should demonstrate them and describe their existence.

Hallock (12) proclaims that a *cutaneous* perforator is any vessel that perforates the outer layer of the deep fascia to supply the overlying skin and subcutaneous tissues. Moreover, the use of the term "perforator flap" is still controversial. (9). According to the Ghent consensus study (10), "a perforator flap is a flap consisting of skin and/or subcutaneous fat. The vessels that supply blood to the flap are isolated perforator (s). These perforators may pass either through or in between the deep tissues (mostly muscle)." The study also states that, even if the skin is not included, the flap can be formed by Scarpa's fascia and subcutaneous fat.

Hofer's classical description of facial artery perforator flaps was limited to perforators leading to the skin. (8). The current definitions of perforator flaps do not include those that terminate in the mucosa, but only those that end in the skin. (11-13)

Furthermore, the use of oral mucosal flaps from the internal side of the cheek area to reconstruct oral defects has been well described by many authors. (14-17) All these flaps are based on the facial artery and its branches. However, their vascular territories have not been established.

Qassemyar, et al. (18) have described the cutaneous territories perfused by perforators from the facial artery. However, the facial artery perforators of the

oral mucosa and the intraoral mucosal territories dependent on these perforators have not been described.

DEFINITION OF NEW TERMS

In the Medical literature we found no references to mucosal perforators or mucosal perforasomes. Perforators are penetrating arteries that emerge from a main vessel, pass through the muscle or another anatomic structure and reach the skin or subcutaneous tissue (9-13). Perforators and perforasomes have been described in other areas but none of the current definitions identify the mucosa as a final destination of a perforator artery.

CLINICAL USE IN SEPTAL PERFORATION SECONDARY TO COCAINE ABUSE.

In relation to the reconstruction of nasal septal defects we should remember that, after cannabis, cocaine is the most commonly used drug in Europe (56,57). The prevalence of cocaine use in Spain in 2011 was 2.2%. (58). It is mainly consumed by younger age groups (59).

The harmful effects of cocaine use are well-established. Special emphasis has been placed on its damage to the brain and cardiovascular system (19, 20). Damage to the central facial region due to cocaine use has been reported, but its management is complicated and is always multidisciplinary (21-24).

The approach to repairing the defects caused by cocaine depends on their size. A wide range of defects has been described, from simple perforations to regional midface necrosis (27,30,31,60, 61).

Septal perforation is a complication of cocaine snorting (25, 26). Other causes reported include inhaled irritants such as chromium (27), systemic diseases, chronic infections (28) and even cancer chemotherapy (29). Mucosal defects range from a clinically asymptomatic state through pinpoint holes to the destruction of the nasal support causing depression of the dome and sinking of the nasal septum or "saddle nose", or even the destruction of the maxilla (30, 31).

Although some authors, such as Mullace et al., reported the use of prosthetic buttons for small and medium-sized perforations (62), other studies have found that they are poorly tolerated in up to 50% of cases (63). Various types of local flap have been tested. However, because of the high risk of failure due to damage to adjacent tissue, the use of distant tissues or even distant free flaps is preferred (65, 66). The problem with remote or free flaps is that their volume may be excessive (31, 65) and reconstruction may be unsatisfactory due to the obstruction to the passage of air. In this case local or distant flaps based on perforators that supply similar tissues could provide the best solution in order to achive a satisfactory reconstruction .

With this study we aim to characterize the perforators from the facial artery to the oral mucosa of the cheek, to describe their nature and to measure not only their anatomical aspects but also their functional territories in order to facilitate the restoration of different defects on the oral and nasal cavity. We also believe this new knowledge could enlight the physiology of the mucosal territories in other body lining segments such as in the vaginal, uretral, intestinal mucosa or others.

HYPOTHESIS

Does the oral mucosa of the cheek have direct perforators arising from the facial artery ?

Null Hypothesis

The oral mucosa of the cheek does not have direct perforators arising from the facial artery.

Alternative Hypothesis.

The oral mucosa of the cheek has direct perforators arising from the facial artery.

OBJECTIVES

The objectives of this study are:

To identify the existence of direct perforators that have their origin in the facial artery on the way to the oral mucosa of the cheek.

To determine the configuration of those perforators that is: their number, diameter and length, and their distribution in relation to the facial artery.

To describe the oral mucosal territories perfused by perforators derived from the facial artery.

To define a new term to denominate the oral mucosal territories perfused by a direct perforator from an artery.

To detail the oral mucosal territories perfused by perforators from the facial artery commenting on their number, location, the mean perfused area and their distribution.

To redesign currently used flaps for reconstruction of the oral, nasal and facial mucosas based on the knowledge of the perforators and their territories.

MATERIAL AND METHODS.

For this study we selected fresh-frozen heads from the department of donation of cadavers from the Universitat Internacional de Catalunya. We used complete heads that had an intact oral mucosa and had not been used for arterial or venous studies. We discarded incomplete specimens or those which had been altered during manipulation in our focus study areas.

Fifteen different heads of fresh-frozen cadavers were used, divided into two groups: one with five heads or ten hemifaces that we call "mucosal perforator group" and the other with ten faces or twenty hemifaces that we call "mucosal perforasomes group".

Each hemiface in the mucosal perforator group was dissected and the perforators of the oral mucosa of the cheek extending from the facial artery (previously injected with latex) were identified.

In the twenty hemifaces in the mucosal perforasome group, oral mucosal perforators of the facial artery larger than 0.5 mm were perfused with diluted ink; the facial artery was dissected from the base of the jaw as far as the branching-off point from the upper labial artery.

CADAVERS

MUCOSAL PERFORATOR GROUP

A submandibular incision was made 2 cm below the lower edge of the jaw. The facial artery and vein were identified at the level of their branching-off points below the edge of the jaw.

INJECTION OF LATEX

Arterial lavage was performed with 30cc of 0.9 saline solution, and two incisions were made at the nasal philtrum to verify fluid outflow. After that, approximately 4cc of LME/R1 latex (Latex Compound Spanish SA Sabadell) was injected, until it was seen out via the nasal incisions. The excess was removed and the sample underwent freezing at -13 ° C for 24 hours.

FIGURE 1

Blue latex specimen. Midline incision in the chin and exposure of oral mucosa. Note the origin of the facial artery (black arrowhead).

An incision was made in the midline of the lower lip and chin (Figure 01). In the oral mucosa at the level of the gingival sulcus a flap was lifted including the periosteum and reaching the sphenomandibular ligament (Figure 02). The

dissection was submucosal in order to reveal the perforators extending from the facial artery to irrigate the oral mucosa.

FIGURE 2

Blue latex specimen . Facial artery dissection and facial artery exposure. The green point corresponds with the oral commisure.

DESCRIPTIVE ANATOMY

The facial artery was identified at its exit point from the mandibular branch. The dissection proceeded in antegrade fashion from the artery to the mucosa up to its anastomosis with the angular artery or its termination.

The diameter of the artery was measured at the base of the jaw. Dissection was performed to identify and preserve the oral mucosal perforators, as well as their origin over the facial artery, taking the base of the jaw as a reference. (Figure 03)

FIGURE 3

Pink latex specimen. Exposure of facial artery and their mucosal perforators (black arrows). Note the branching-off site of the superior labial artery and the inferior labial artery (empty arrowheads), and the emergence of the facial artery (double black arrowheads).

The perforators from the upper and lower labial arteries were not examined.

MUCOSAL PERFORASOMES GROUP

The skin incisions were made following a facelift pattern. Two incisions were added, the mucosal perforator from one of a "crow's foot" to the ipsilateral tragus, and the second one four finger widths below the horizontal branch of the mandible. (Figure 04)

FIGURE 4

Preauricular flap design with a superior extension to the orbital rim and an inferior line below the inferior mandible line.

We performed a supra-SMAS dissection and all superficial perforators that could be identified were ligated. In this way, all the mucosal perforators were preserved. (Figure 05)

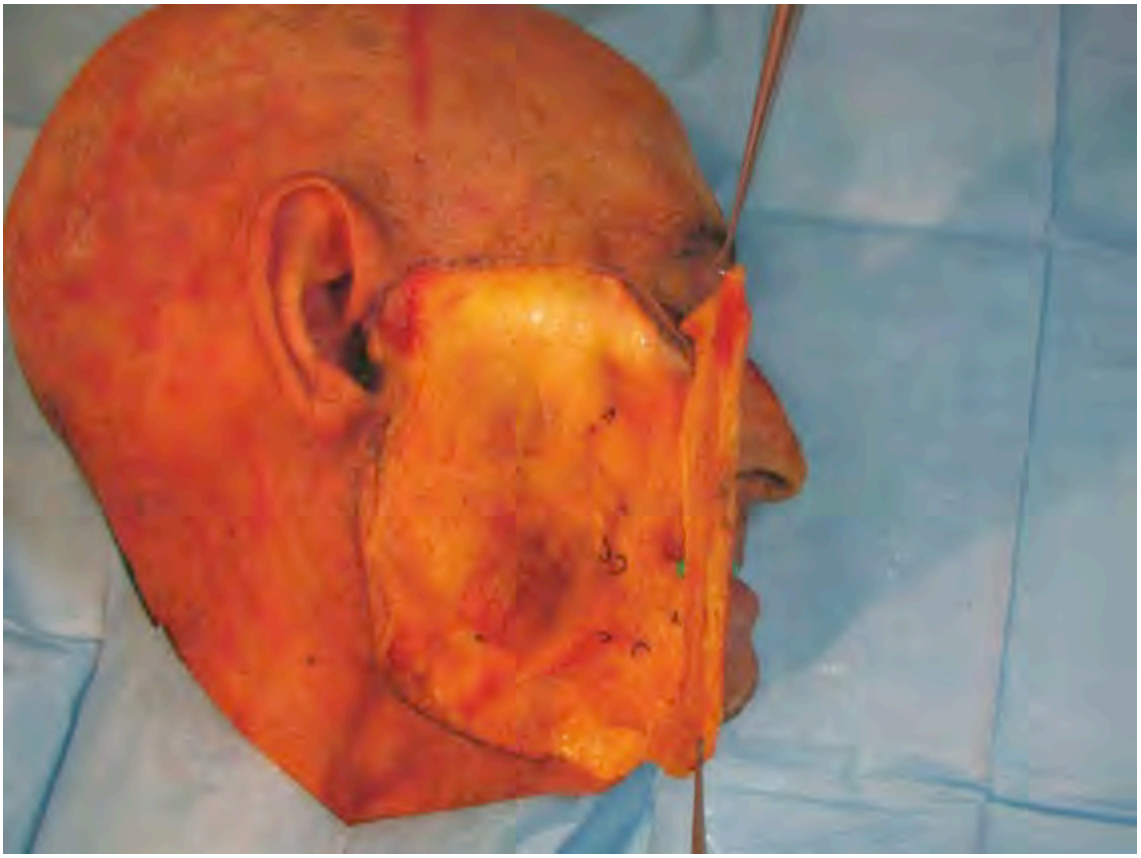

FIGURE 5

Raising of skin flap and ligation of cutaneous perforators. In green, the oral commisure is marked.

The inferior and superior labial arteries were ligated after identification.

DESCRIPTIVE ANATOMY

The length of the facial artery was measured from the lower edge of the jaw until the exit point of the superior labial artery. The diameter of the facial artery was measured at three levels: the base of the jaw, the oral commissure and the exit point of the superior labial artery. The number of oral mucosal perforators was identified, as was their origin over the facial artery, taking the branching-off site of the superior labial artery as a starting point (Figure 06)

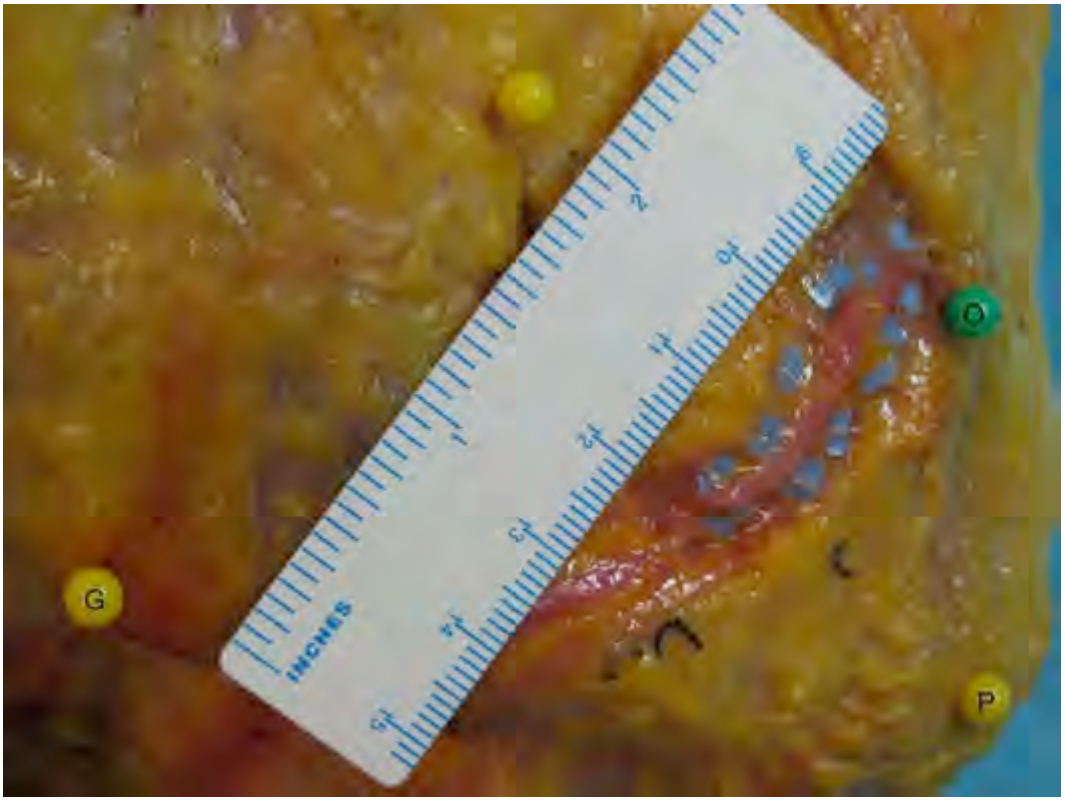

FIGURE 6

Dissection of the facial artery tree and identification of its branches and perforators. In yellow, the gonion (G), pogonion (P), in green, the oral commissure (O).

For identification, three points were taken as landmarks: the gonion, the pogonion, and the oral commissure. A line was traced between gonion and pogonion at the base of the jaw, and another parallel line from the oral commissure.

SELECTIVE INK INJECTIONS

FIGURE 7

The selected perforators were closed with clamps and diluted ink was used.

Perforators larger than 0.5 mm were selected and were perfused with 1cc of diluted ink (Figure 07) After each injection; the presence of coloring in the oral mucosa was examined. (Figure 08) If coloring was observed, the area was identified and measured. Different colors were used to distinguish each area (Gouache; Royal Talens, Apeldoorn, Netherlands).

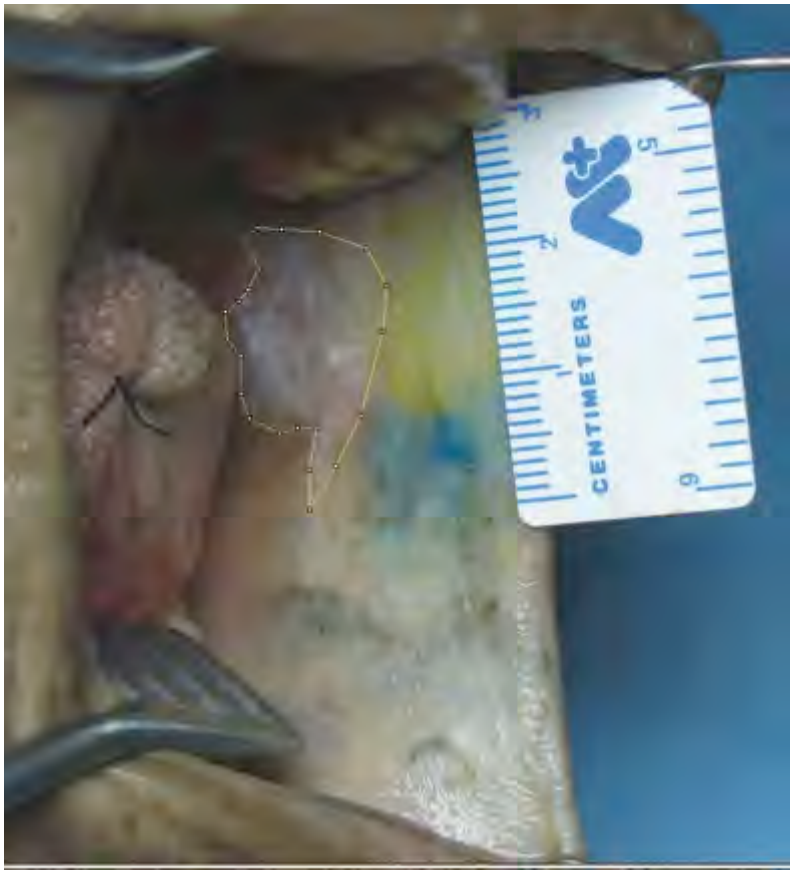

FIGURE 8

Identification and measuring of a specific area on the oral mucosa (white). We used the ruler as a patron to obtain a scale that can be used on the image processor. We can see four mucosal perforasomes

MEASUREMENTS

The Image J software version 1.45s was used (W. S. Rasband, ImageJ, U.S. National Institutes of Health, Bethesda, Md., http://rsb.info.nih.gov/ij)

The measurements were made with two photographs taken at a distance of 30 cm from the specimen. After obtaining the scale and the conversion rate, the program converted the measurements into the distances or areas registered.

STATISTICAL ANALYSIS

We used the STATA program version 11.1(Lakeway Drive, Texas, USA). The Shapiro Wilk test and the normal probability plot technique were performed to

assess the normality of the variables. If the distribution of the variables was normal, the Pearson's test was used. When distribution was non-normal, Spearman's rank correlation coefficient was used to evaluate the results. A $p < 0.05$ was considered to indicate statistical significance in all cases.

To determine the branching-off sites of the superior and inferior labial arteries, the guide points described previously were used. Means, standard deviations, and 95% confidence intervals were calculated. Tolerance limits were also obtained with a 95% confidence that 95% of the general population were within the limits determined.

FLAP HARVESTING

After the facial artery dissection and selective ink injections on the 20 hemifaces in the mucosal perforasomes group , the total stained area was determined. With this area two types of musculo-mucosal flaps were made. The first one was based on the proximal facial artery, by ligating the facial artery just before the branching-off site of the superior labial artery and including the mucosa and the buccinator or orbicularis muscle, as appropriate. The second, the reverse-flow flap, was made by sectioning the facial artery just after the branching-off site of the inferior labial artery; in the absence of this artery, the facial artery was sectioned above the lower edge of the stained oral mucosa.

The arc of rotation of these flaps was assessed and the anatomical sites that the flaps could reach to cover a hypothetic defect were identified.

DEFINITION OF THE TERM MUCOSAL PERFORASOMES.

We performed a systematic review of the literature through the PubMed database searching for articles with the keywords "perforator mucosa", "mucosal perforator", "oral mucosa perforator", "oral mucosal perforator", "oral mucosa perforator flap" and "oral mucosal perforator flap". In the articles found, we looked for descriptions of mucosal perforators or mucosal perforasomes.

In the same database we searched for the keywords "perforasome" and "perforasomes". We examined each of the references to see whether they described mucosal perforator flaps, mucosal perforators, or mucosal perforasomes.

In the Cochrane Library we also searched for the terms "mouth mucosa" and "flap perforators" to identify references.

CLINICAL USE IN SEPTAL PERFORATION SECONDARY TO COCAINE USE.

In a clinical setting we selected five clinical cases with septal perforations due to cocaine use. As inclusion criteria they reported quitting their noxious habit. Follow-up was made on the patients for at least 6 months. The endpoint was restoring of defect in the nasal septum.

FIGURE 9

Marking of the facial artery on the oral mucosa. We use a non-directional Doppler with an 8 MHz probe.

Using a Doppler probe, in the oral mucosa we mark the path of the facial artery. (Figure 09) We make the same mark on the skin of the cheek, from the exit of the artery at the base of the jaw to its termination in the nasal ala or its anastomosis with the angular artery. This will help us later in the identification of the bifurcation of the superior labial artery, which will be near the oral commissure. (Figure 10)

FIGURE 10

Marking of the facial artery on the cheek skin and the bifurcation of the superior labial artery. We start the searching at a point 7.4 mm lateral and 5.1 mm above the oral commissure.

We harvest the musculo-mucosal flap extracting an area about 20% larger than the defect that we aim to cover. (Figure 11) We attempt to ligate the facial artery in the gingival sulcus, taking care not to damage the perforators next to the buccinator and orbicularis muscles.

FIGURE 11

Flap harvested to reconstruct the septal defect. We select an area 20% larger than the defect we intend to reconstruct.

We perform a retrograde dissection of the facial artery, taking extreme caution at the branching off site of the superior labial artery bifurcation.

Once we reach the bifurcation of the superior labial artery we ligate it and continue the dissection over the facial artery to the base of the nasal ala or to a point where we can easily insert our flap inside the nose.

An incision is made at the base of the nasal ala on the alar margin to allow correct placement of the flap. On the septal orifice, we excise the borders of the defect until we find healthy tissue. If possible we lift the septal periorificial mucosa on the perimeter of the orifice 5 mm to insert the flap facing the raw surfaces. We attach our flap with strategically placed sutures (eight to ten stitches). (Figure 12)

FIGURE 12

Insertion of the flap in the septal defect.

At this point, if required, we modify the nasal tip by open rhinoplasty. Similarly, if cartilage grafts are required for the nasal dorsum, and grafts or local plasty to release the nostrils, reconstruction is performed. In one case a local graft based on the palatine artery was required to cover a defect in the palate.

The donor site is closed in layers with absorbable stitches. Depending on the amount of mucosa obtained, this procedure may range from a simple closure (the most common case) to a local V-Y plasty.

After surgery a standard splinting is applied to the nose and a gauze is left in place impregnated with antibiotic, without compressing the flap. This gauze is removed within 24 hours. The flap is evaluated daily in the first 72 hours.

RESULTS

CADAVERS

The group "cadavers" includes fifteen heads, or thirty hemifaces divided as follows: ten hemifaces treated with latex in the "mucosal perforator group"; and the twenty hemifaces called "mucosal perforasomes group", this group was studied wih diluted ink.

MUCOSAL PERFORATOR GROUP

In this group with ten hemifaces we measured the diameter of the facial artery at the base of the mandible, its length, from its exit point up to its anastomosis with the angular artery or its termination. The total number of mucosal perforators found on each artery was registered. We measured each perforator and determined the diamenter at its exit point and its length to the mucosa. We verified in each hemiface the existence of the superior labial artery and the inferior labial artery.

The mean diameter of the facial artery at its base was 2.47 mm ± 0.32. Its mean length from the base of the jaw to its termination or in its anastomosis with the angular artery was 119.30 mm ± 12.40 mm. Fifty-two oral mucosal perforators from the facial artery were found in the ten hemifaces. The mean number of mucosal perforators per facial artery was 5.2 ± 1.14. The mean diameter was 0.50 mm ± 0.16, and the mean length of the perforators from their point of emergence to the mucosa was 16.42 mm ± 5.33. (Table 01)

Table 01. Overview of facial artery and mucosal perforators in the Mucosal Perforator Group

Dissection N	Diameter	Facial Artery Total Length	Mucosal Perforators Number	Diameter	Length
1	2.01	122.08	4	0.57 ± 0.23	20.28 ± 2.53
2	2.55	107.99	6	0.43 ± 0.12	18.48 ± 7.38
3	2.33	98.86	7	0.48 ± 0.23	11.53 ± 1.51
4	2.03	105.53	4	0.41 ± 0.15	21.67 ± 3.87
5	2.53	130.29	5	0.60 ± 0.10	20.10 ± 2.68
6	2.33	117.51	7	0.53 ± 0.12	10.77 ± 5
7	2.39	134.82	5	0.49 ± 0.05	17.62 ± 1.93
8	2.79	115.90	4	0.48 ± 0.10	14.75 ± 3.91
9	2.92	125.72	5	0.59 ± 0.14	16.07 ± 1.76
10	2.83	134.27	5	0.48 ± 0.25	18.20 ± 6.32
Mean	2.47	119.30	5.20	0.50	16.42
SD*	0.32	12.40	1.14	0.16	5.33

*** Standard deviation**
Results are expressed in millimeters mean ± standard deviation.

Most of the mucosa of the cheek was perfused directly by perforators of the facial artery. The mucosa of the lips was perfused by perforators from the labial arteries, although these arteries were not the subject of our study.

The superior labial artery was found in all cases. In two cases, the inferior labial artery was not found; in both these cases, the sublabial artery was identified.

MUCOSAL PERFORASOMES GROUP

In this group with twenty hemifaces we identified the dissection and the sex of the cadaver. We measured the diameter of the facial artery, at different levels. The length of the facial artery from the inferior border of the jaw to the exit point of the superior labial artery. We recorded also the number of perforators larger than 0,5 mm in diameter that arise from the facial artery towards the oral mucosa.

Table 02. General description of facial artery in the Mucosal Perforasomes Group

Dissec-tion	Sex	FA diameter at mandible (mm)	FA diameter at oral commissure (mm)	FA diameter at origin SLA (mm)	Length of FA from mandible to superior labial artery (mm)	N of FAMP > 0.5 mm
1	M	2.3	1.9	0.9	62.3	2
2	M	2.98	1.5	1.25	52.2	2
3	M	3.65	1.71	1.37	59.05	2
4	M	2.74	1.91	0.98	57.93	5
5	M	2.44	1.61	1.25	63.98	6
6	M	2.55	1.9	1.11	64.58	5
7	M	2.51	1.62	1.23	63.3	5
8	M	2.71	1.68	0.96	64.96	3
9	F	2.86	1.64	1.2	66.22	3
10	F	2.23	1.76	1.1	61.71	3
11	F	2.24	1.56	0.97	65.23	5
12	F	2.51	1.59	1.28	74.77	3
13	F	2.73	2.03	1.35	60.72	3
14	F	2.5	1.85	1.7	58.98	4
15	M	3.06	1.71	1.67	65.19	4
16	M	2.62	1.63	1.59	74.87	4
17	F	3.51	2.68	1.58	67.43	4
18	F	2.67	1.87	1.49	64.27	5
19	F	2.96	1.61	1.27	49.56	4
20	F	3.03	1.42	1.39	56.82	2
Mean		2.74	1.76	1.28	62.7	3.7
SD*		0.37	0.27	0.23	6.03	1.19

*** Standard deviation; FA: Facial Artery; SLA: Superior Labial Artery; FAMP: Facial Artery Perforators Mucosal perforators measuring more than 0.5 mm**

The diameter of the facial artery was 2.74 ± 0.38 mm at the base of the jaw, 1.76 ± 0.27 mm at the oral commissure, and 1.28 ± 0.24 mm at the bifurcation of the superior labial artery. The mean length of the facial artery from the base of the jaw to the point of emergence of the superior labial artery was 62.70 ± 6.18 mm. The

mean number of perforators larger than 0.5 mm was 3.70± 1.22. In six cases we found a fifth oral mucosal perforator, and in one case a sixth (Table 02).

As previously, we corroborated the existence of the superior and inferior labial arteries and determined the exit point of the superior labial artery based on a line beginning on the mouth commissure, and parallel to the inferior border of the mandible.

The superior labial artery branched bilaterally from the facial artery in all cases. Taking the oral commissure as reference, the branching-off site of the superior labial artery was identified 7.4 mm laterally and 5.1 mm above a line parallel to the lower edge of the jaw, between the gonion and pogonion. Using inferential statistics to determine the branching-off site of the superior labial artery in the general population from our sample, with a 95% confidence interval, we predicted the point of emergence of the upper labial artery within an area of 3 sq cm in the general population. With tolerance limits of ± 9.98 and ± 7.60 (Table 03)

The inferior labial artery was present bilaterally in eight of ten heads. In the other two cases the inferior labial artery was absent and the sublabial artery was identified. The mean point of emergence of the inferior labial artery was 24.19 mm lateral to the oral commissure and 9.60 mm above the lower edge of the jaw, on a line from the gonion to the pogonion. Using inferential statistics to determine the branching-off site of the inferior labial artery in the general population from our sample, with a 95% confidence interval, we obtained two statistical tolerance limits of 5 cm in the horizontal dimension (± 24.63) and 3 cm in the vertical dimension (± 15.04) and (Table 03)

Table 03. Statistical analysis of measurements relative to point guides

Artery	Surface Landmark		Nº of Dissec-tions	Mean Value (mm)	SD (mm)	95% Confidence interval p<0.05	95% Toler-ance limits p<0.05
Superior labial artery	Oral Commissure	Lateral	20	7.40	± 3.63	± 1.70	± 9.98
	Oral Commissure*	Superior	20	5.12	± 2.76	± 1.29	± 7.60
Inferior labial artery	Oral Commissure	Lateral	20	24.19	± 8.95	± 4.19	± 24.63
	Base of jaw	Superior	20	9.60	± 5.46	± 2.56	± 15.04

*** A line parallel to the base of the jaw is used** **SD: Standard Deviation**

In the mucosal perforasomes group comprised by twenty hemifaces we assessed the number of mucosal perforators larger than 0,5 mm. We quantify their diameter, and we perfuse each one of them with diluted ink and determined the perfused area by colouring. Seventy-four perforators were measured. The mean diameter of the perforators at the branching-off site from the facial artery was 0.53± 0.19 mm. The 74 perforators were perfused and the mean area per perforator was 279.72± 156.24 sq. mm. We stress that the perforators were measured from the branching-off site from the superior labial artery and that only the ones larger than 0.5mm were selected. (Table 04)

The first two perforators were found in all cases, i.e. in all twenty hemifaces. The first perforator was found at a mean distance of 4.51 ± 2.90 mm , and the second perforator at a mean of 10.34 ± 4.19 mm. In sixteen cases a third perforator was found at a mean of 16.65 ± 4.01mm, in 11 cases a fourth at a mean of 23.10 ± 5.23 mm, in six cases a fifth at 31.74 ± 5.31 mm and in only one case a sixth at 40.92 mm.

Table 04. Analysis of mucosal perforators in order of appearance. *

FAPM Position	N	FAPM origin over the course of FA (mm)	Diameter (mm)	Anatomical localization				Coloured skin surface (mm^2)
1st	20	4.51 ± 2.90	0.52 ± 0.20	45.00%	Antero-superior	90%	Anterior zones	379.23 ± 182.55
				45.00%	Antero-medial			
				10.00%	Middle superior	10%	Middle zone	
2nd	20	10.34 ± 4.19	0.55 ± 0.21	35.00%	Antero-medial	65%	Anterior zones	305.83 ± 161.84
				30.00%	Antero-inferior			
				20.00%	Middle superior	30%	Middle zones	
				10.00%	Middle inferior			
				5.00%	Posterior			
3rd	16	16.65 ± 4.01	0.52 ± 0.19	25.00%	Antero-inferior	25%	Anterior zones	187.02 ± 73.25
				50.00%	Middle superior	69%	Middle zones	
				18.80%	Middle inferior			
				6.30%	Posterior	6%	Posterior zone	
4th	11	23.10 ± 5.23	0.49 ± 0.15	36.40%	Middle superior	82%	Middle zones	235.05 ± 99.77
				45.50%	Middle inferior			
				18.20%	Posterior	18%	Posterior zone	
5th	6	31.74 ± 5.31	0.49 ± 0.13	50.00%	Middle inferior			211.12 ± 105.58
				50.00%	Posterior			
6th	1	40.92		100.00%	Posterior			153.36
Total	74		0.53 ± 0.19					279.72 ± 156.24

FAPM, facial artery perforators of the oral mucosa; FA, facial artery.
*** Measurement starting from the bifurcation of the superior labial artery. Results are expressed in millimetres as the mean ± standard deviation.**

The perfused areas in the oral mucosa were classified in six main types: three anterior areas near the oral commissure and the lips (superior, media and inferior), two medial areas (superior and inferior) and one near the molars. (Figure 13)

The first and second perforators perfused in most cases the anterior zone perforasomes (90% and 65% respectively), whereas the third and fourth perforators perfused the middle zone perforasomes (69% and 82 % respectively). The posterior perforasome had various origins. (Tables 04 and 05)

FIGURE 13

Diagram of the oral mucosal perforasomes. The anterior area is divided into three areas and the medial area into two; the posterior area is not divided. The total area of perfused oral mucosa is between the canines and a point halfway along a line linking the two points of attachment of the second and the third molar.

FIGURE 14

We can see 2 mucosal perforasomes colored with blue ink and yellow ink.

Table 05. Distribution of oral mucosal perforasomes.The ordinal number is assigned as the mucosal layer was colored.

		P E R F O R A S O M E S					
Dissection N	**Perfo-rators N**	**antero superior**	**antero medial**	**antero inferior**	**middle superior**	**middle inferior**	**posterior**
01	2		1			2	
02	2				1		2
03	2				1	2	
04	5	1	2	3	4	5	
05	6	1	2	3	4	5	6
06	5	1	2		3	4	5
07	5		1	2	3	4	5
08	3		1		2	3	
09	3		1	2		3	
10	3		1	2	3		
11	5		1	2	3	4	5
12	3		1		2	3	
13	3	1			2		3
14	4	1		2	3	4	
15	4		1	2	3		4
16	4	1	2		3		4
17	4	1	2	3		4	
18	5	1	2	3	4	5	
19	4	1	2		3	4	
20	2		1		2		
TOTAL	**74**	**9**	**16**	**10**	**17**	**14**	**8**

The stained area corresponded to a triangle of oral mucosa located between the canines and a point halfway along a line between the second and third upper and lower molars. (Figure 14 and 15) .

FIGURE 15

Five stained areas. They correspond with the anterior zones: antero-superior (*yellow*), antero-medial (*blue*) and antero-inferior (*red*), and with the middle zones: middle-superior (*white*) and middle-inferior (*black*). The total stained area represents the area perfused by the mucosal perforators from the facial artery.

FLAP HARVESTING

The proximal flaps of the facial artery had an arc of rotation covering as far as the mid line of the lower lip, the oral commissure, and the posterior third of the palate. (Figures 16-18) The reversal-flow flaps reached the upper lip, the two anterior thirds of the palate, the nasal septum and the superior palpebral conjunctiva. (Figures 19-21)

FIGURE 16

Proximal oral mucosal flap for reconstruction of the oral commissure. The total area is shrunk by the elasticity properties of the mucosa.

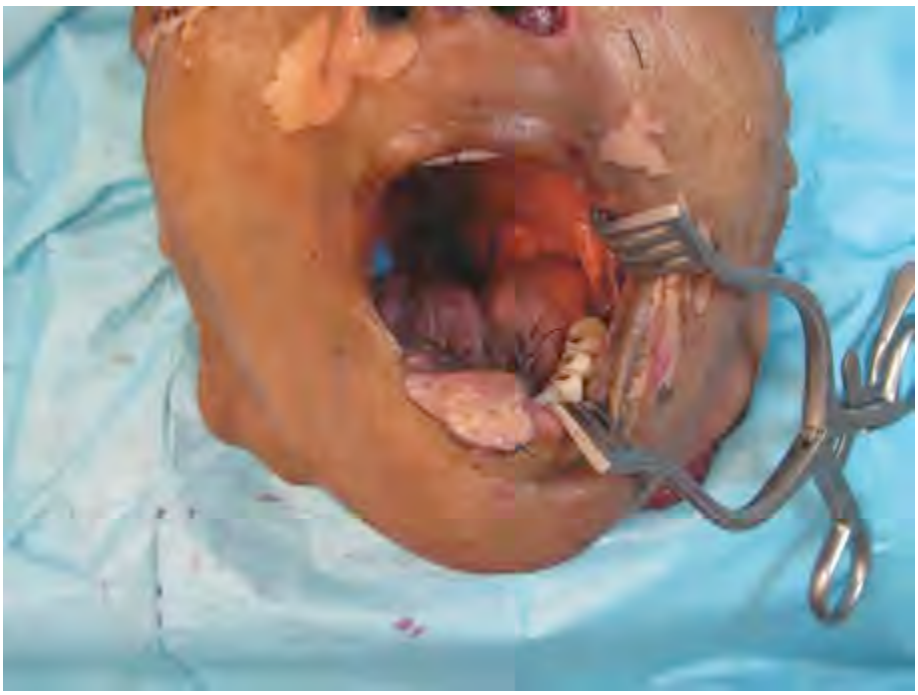

FIGURE 17

Proximal oral mucosal flap for reconstruction of the lower lip.

FIGURE 18

Proximal oral mucosal flap for reconstruction of the posterior third of the palate. Note the pedicle over the light-blue insert.

FIGURE 19

Reverse flow oral mucosal flap for reconstruction of the two anterior thirds of the palate. We can see the mucosal flap based on mucosal perforators stained with yellow and blue.

FIGURE 20

Reverse flow oral mucosal flap for reconstruction of the nasal septum. In this specimen we open the nasal alae to position our flap and provide clear exposure. The pedicle is over the blue insert.

FIGURE 21

Reverse flow oral mucosal flap for reconstruction of the palpebral inferior conjunctiva. We make an incision next to the nasal ala to expose the pedicle.

STATISTICAL ANALYSIS

MUCOSAL PERFORATOR GROUP

A statistically significant inverse correlation was found between the position of the mucosal perforator over the facial artery from the lower edge of the jaw and the length of the perforator ($p < 0.05$). (Figure 22)

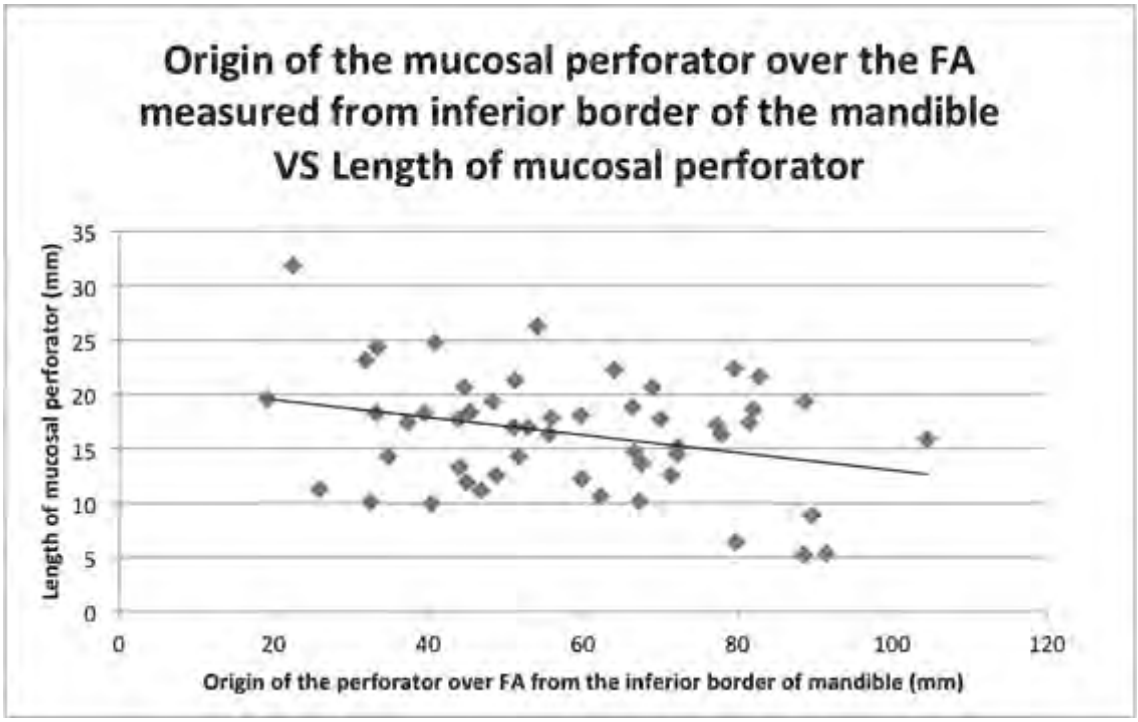

FIGURE 22

Relation between the position of the mucosal perforator over the facial artery (FA) from the lower edge of the jaw and the length of mucosa perforator. ($p<0.05$)

No significant correlations were found between the diameter of the facial artery and its total length or the number of perforators. Nor were there statistically significant correlations between the length and the diameter of the mucosal perforators, or between the position of the perforator over the facial artery and the perforator's diameter.

MUCOSAL PERFORASOMES GROUP

There was a statistically significant correlation between the diameter of the artery at the base of the jaw and at its branching-off point from the superior labial artery ($p<0.05$). (Figure 23)

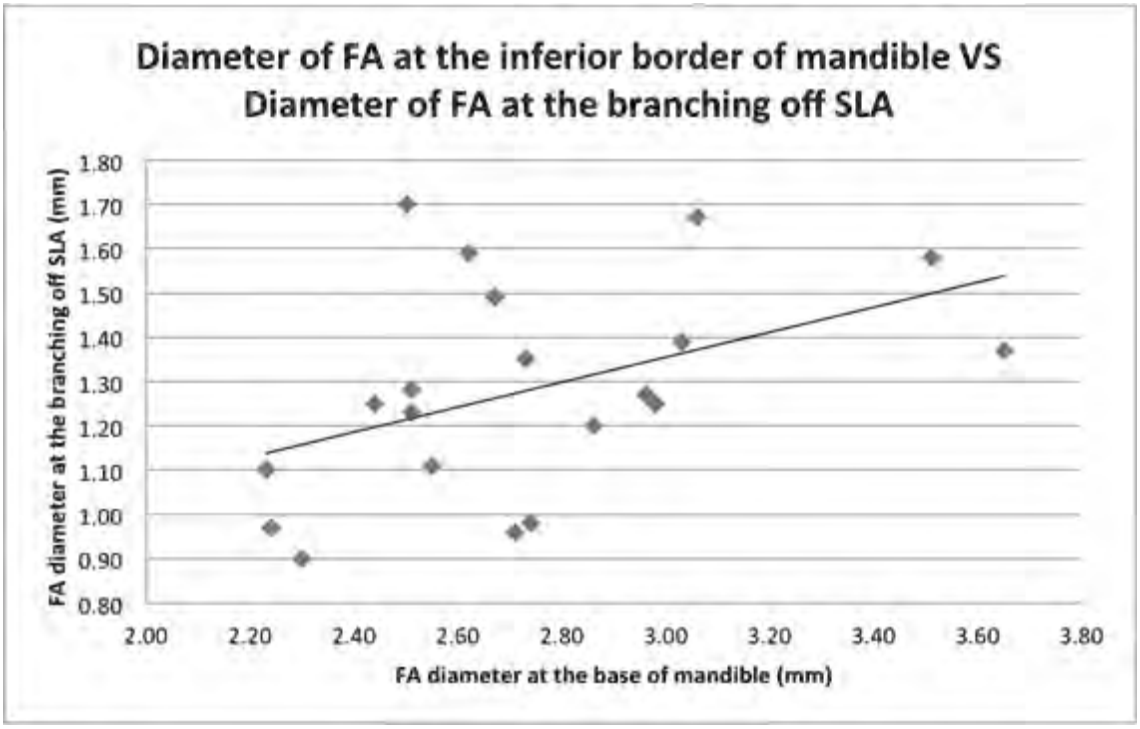

FIGURE 23

Relation between the diameter of the facial artery (FA) at the base of the mandible and its diameter at the exit of the superior labial artery (SLA).

The Spearman's rank correlation coefficient showed a significant inverse correlation between the distance from the exit point of the perforators starting at the branching-off point of the superior facial artery and the stained areas of the oral mucosa ($p<0.001$). (Figure 24)

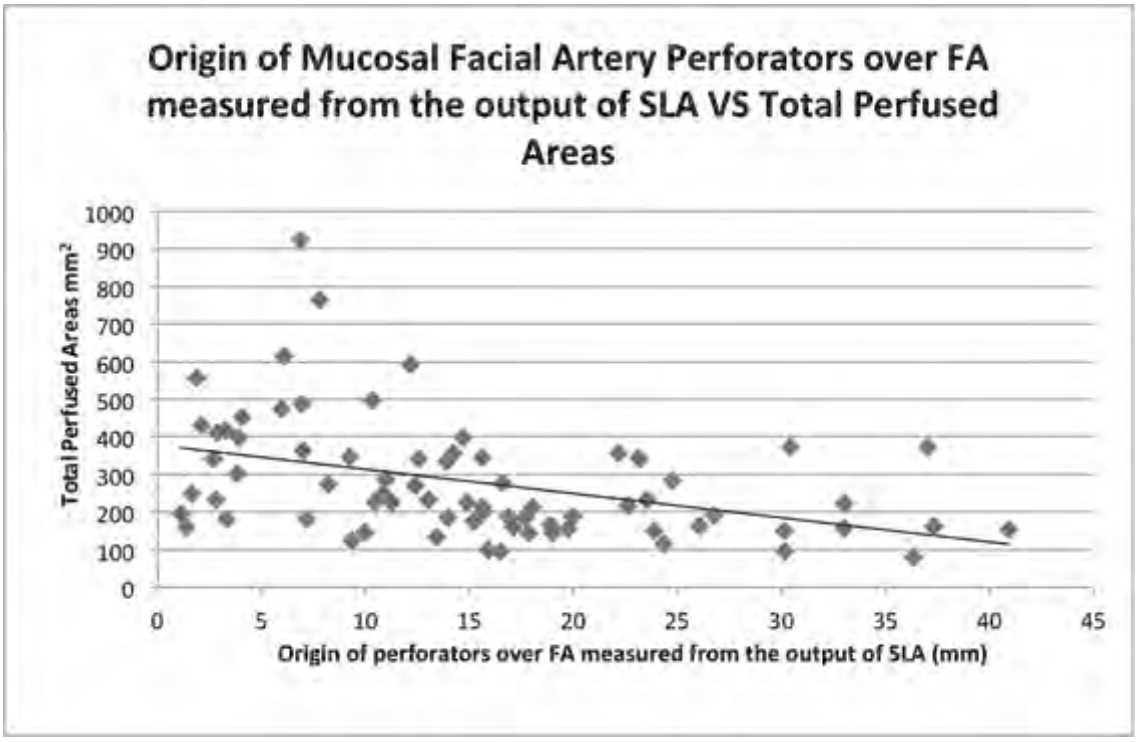

FIGURE 24

Relation between the mucosal oral perforators of the facial artery over the facial artery (FA) and the perfusion areas in the mucosa measured in mm^2. ($p<0.001$).

No statistically significant correlations were found between the facial artery diameter and its length until the superior labial artery. Nor was there a statistical correlation between artery diameters measured at the three points described above and the length of the artery, nor between these diameters and the number of perforators larger than 0.5 mm, nor between the diameter of the perforators and the perfused areas.

DEFINITION OF THE TERM MUCOSAL PERFORASOMES.

In the Pubmed search on the 24th September 2015, the key words "mucosa perforator" yielded twenty-three articles. We found fifteen articles using "oral mucosa perforator", seventeen articles using "oral mucosa perforator", and nineteen articles using “oral mucosal perforator”. The key words "oral mucosa

perforator flap" and "oral mucosal perforator flap" yielded seventeen and fifteen articles respectively.

From nineteen articles of bibliographical data two articles were excluded because they are our own descriptions and include our definitions. Seventeen articles were identified (8-24). Fifteen described the reconstruction of the oral area with cutaneous perforator flaps from other areas of the body. The other two described the reconstruction of the oral mucosa with local flaps. They did not mention mucosal perforators or perforasomes.

With the key words "perforasome" and "perforasomes" each yielded nine articles, before 14th June 2013. On 24th September 2015 the word “perforasome” returned sixteen results, and the word “perforasomes” generated thirteen sources. Two of them refer to our articles. In all, sixteen articles were identified (25-40). There were no references to mucosal perforasomes. None of the references quoted in these articles mentioned mucosal perforators or their perforasomes except for our own work.

The search in the Cochrane Library with the terms "mouth mucosa" and "flap perforators" did not find any results. None of the articles referred to the perforating arteries of the mucosa, to the areas perfused, or to mucosal perforasomes.

CLINICAL USE IN SEPTAL PERFORATION SECONDARY TO COCAINE ABUSE.

We saw five cases with septal perforations due to cocaine use. (Table 06).

Table 06. General description of the patients.

N	Sex	Age	Defect (mm)	Abstention Time (months)	Follow-up (months)	Procedures
1	Female	22	20 x 16	6	22	MPBF
2	Female	25	22 x 15	12	14	MPBF, PAF, cartilage graft
3	Female	28	25 x 12	30	15	MPBF, open rhinoplasty
4	Male	36	31 x 23	20	18	MPBF
5	Female	40	22 x 12	24	34	MPBF
Mean		30.2	24 x 15.6	18.4	20.6	

MPBF: Mucosal Perforasomes Based Flap; PAF: Palatine Artery Flap, mm: millimeters

Mean age was 30.2 years. Four were female and one male (Figures 25 and 26). They reported quitting their cocaine habit on average 18 months previously. The mean septal perforation was 24 x 15.6 mm. Patients were followed for a mean of 20.6 months (range 15-34 months). (Figure 25)

FIGURE 25

Clinical case with a complex defect in the hard palate and the nasal septum..

FIGURE 26

Satisfactory evolution of the former patient.

We use a palatine axial flap to close the palate and a mucosal-based perforator flap (MPBF) to reconstruct the nasal septum, both performed in the same surgical procedure

FIGURE 27

Preoperative views on top and bottom left . Post-operative views on top and bottom right at 10 months follow-up, demonstrating improvement in the nasal shape and correction of the palatal defect. Restoration of the defect and nose reconstruction was achieved.

DISCUSSION

MUCOSAL PERFORATORS AND MUCOSAL PERFORASOMES

Admittedly, surgeons need to base their surgical practice upon accurate anatomical knowledge. But what happens when our anatomical knowledge is erroneous ? For many centuries our knowledge about the anatomy of the human vessels was based on erroneous ideas. Even Galen made some mistakes in describing the pulmonary circulation and the errors remained for centuries, until other anatomists, such as Michael Servetus and Ibn al-Nafis, refuted his ideas (32). Later on, some misconceptions were refuted by Harvey in his book *Exercitatio Anatomica de Motu Cordis et Sanguinis in Animalibus* (33). In this book "Harvey frequently explains experimental procedures in a way that invites the reader to reconstruct them in his mind or perhaps to perform them," as Jole Shackelford explains, in a book about the history of William Harvey (34).

A thorough knowledge of vascular anatomy is crucial to the understanding and performance of any kind of surgical act and especially so in perforator flap surgery. Many studies on this subject have been published recently. (35-38) The perforator flaps allow primary closure of some defects and, more importantly, the use of the reconstructive principle of replacing "like with like" tissues**.**

To date, the study of facial perforators has focused on those that terminate in the skin. (8) This study demonstrates that there are also perforators that terminate in the oral mucosa. These perforators are slightly narrower and shorter than those in the facial skin. (8,18,39).

The concept of “mucosal perforator flap” does not exist. Moreover the concept of a perforator flap is not standardized: at present, the only variables included in all definitions are the skin and/or the subcutaneous tissue. Sinna (9) states “It is clear from the international literature that various authors have failed to agree on what qualifies as a perforator flap.” The Gent Consensus(10) in its introduction, affirms that “because the area of perforator flaps is new and rapidly evolving, there are no definitions and standard rules on terminology and nomenclature, which creates confusion when surgeons try to communicate and compare surgical techniques.” Wei (11) express concern about what is a true perforator flap .Giunta and Hallock (12-13) manifest the same doubts.

The latex injection technique remains useful for identifying the territories perfused by an artery. Bergeron in a review, underlines the importance of latex in the dissection process but makes known that “latex only allows visualization of blood vessels and does not allow gross visual assessment of the skin territory perfused by a given vessel”(40, 41) To overcome that handicap we diluted the latex in order to reach the small perforators, but it remained excessively dense and was unable to perfuse the more distal areas in the mucosal plexus. As a consequence, we designed another protocol with diluted ink to obtain proper results in that part of the study.

In clinical cases with living patients the possibility of using color Doppler techniques to define the course of the facial artery has already been proposed.(42) CT allows better characterization of the facial artery (43) but these techniques are of little use in vessels with a caliber of less than 1 mm. (44) Therefore in our study we tried to define a landmark useful for this kind of vessels. In our study we

determined the emergence of the mucosal perforators of the facial artery by injection with latex and determined their relative position in relation to the other elements near the region. We observed the majority of perforators between the branching-off site of the superior labial artery and the inferior labial artery or sublabial artery in the case of the abscense of the inferior labial artery. This data suggests a guide point based on the emergence of the labial arteries for the localization of mucosal perforators from the facial artery.

In all cases, the superior labial artery branched off bilaterally from the facial artery. Our data corroborate those of most other reports; (45,46) they diverge slightly from those described by Magden (47), probably because those authors used preserved formalin cadavers rather than fresh frozen heads. When formalin is used for tissue processing, the most important problem is inadequate tissue dehydration (69) and that is reflected in the shrinkage of the specimen.

Using inferential statistics we were able to predict the branching-off site of the labial superior artery in an area 2 cm long and 1.5 cm high with a surface area of 3 sq cm for 95% of the general population. This method was reported by Whetzel (48) for the description of certain perforators of the facial region.

We do not advise the use of the inferior labial artery as a guide point because, in spite of the fact that in the majority of cases it was present bilaterally, in two cases it was not identified. This is consistent with the great variability of the artery described by Edizer. (49) The branching-off site of the inferior labial artery was less predictable: statistically, the tolerance limits for determining an area with 95% confidence for individuals in a population were 3 cm in height and 5 cm in length, i.e. the branching-off site could be in an area of around 15 sq. cm.

The perfused areas matched with the number of mucosal perforators selected. After studying the 74 stained territories in all the cadavers, it was clear that the perfusion was different in each cheek, and even in the same corpse. They were most consistently found in the anterior areas; the first pair of perforators perfused mainly the anterior perforasomes and the next two the medial perforasomes. This may be because, in the light of previous descriptions, it was decided to select only mucosal perforators larger than 0.5 mm. (8,18)

The mean area perfused by each perforator was 279.72 sq. mm., which is notably lower than the cutaneous territories. The six areas of perfusion were similar to the pattern described in the skin (8) and are compatible with Saint-Cyr's perforasome theory. (50) The posterior perforasome probably shares perfusion with the buccal artery or the anastomosis between the buccal and facial artery described by Zhao. (16) This could explain the diverse sources of perfusion for the posterior territory.

In those cases where only two or three perforators larger than 0.5 mm were found, the total stained area invariably reproduced the triangle-shaped zone between the canines and a point halfway along a line between the second and third upper and lower molars. All of the cheek mucosa inside that triangle could probably be elevated as a flap on these two or three perforators. The blood supply to the whole mucosa triangle would be provided by the direct and indirect linking vessels, as described for other perforator flaps. (51,52)

In agreement with Qassemyar, we did not find any statistically significant correlation between the diameter of mucosal perforators and the perfused areas. In the same way, we found a statistically significant *inverse* correlation between the origin of the perforator and the perfused area. Also we found a statistically

significant correlation between the origin of the mucosal perforator above the facial artery and the length of the mucosal perforator. That is, the perforators nearest the branching-off site of the superior labial artery were shorter than the perforators next to the base of the mandible. This finding is relevant to the selection of the proximal perforators when a longer pedicle is needed.

Whetzel (53) proposed that the primary arterial supply to the oral mucosa of the cheek was provided by the buccal and labial arteries. Our data demonstrate that the mucosal perfusion of the cheek is done with perforators from the facial artery after the branching-off point from the inferior labial artery and before the exit point of the superior labial artery, since the labial arteries had been previously ligated to exclude their arterial supply to the mucosa of the cheek. Therefore, we should not dissect beyond the superior labial artery or the inferior labial artery (depending on our flap design) when we want to ensure the perfusion of a flap based on the facial artery perforators for the mucosa of the cheek. The labial arteries provide similar perforators for the labial mucosa, so that we can harvest more mucosa when we need more oral mucosa for some reconstruction.

Pribaz (14, 54) describes the FAMM flap for the reconstruction of the oral mucosa based on the facial artery. However, the maximum amount of mucosa that can be harvested has not been described. Landes et al. (15) have described the dorsally-pedicled buccal musculo-mucosal (DPBM) flap and have stated that this flap is supported by the submucosal plexus and, for that reason, a thin layer of buccinator is included to preserve that plexus. We could assume that the plexus is eventually supported by the musculo-mucosal perforators from the facial artery. Matros (55)

reports a technique for placing the pedicle in patients with intact dentition and avoiding two-stage reconstruction. Zhao(16) describes the buccinator myomucosal island flap for harvesting mucosa from the same zone to perform diverse reconstructions of the oral cavity and beyond. However, they did not describe either the oral mucosal perforators of the facial artery or the areas they perfuse.

Here we describe the maximum amount of mucosa that can be harvested to perform a reconstruction, reflected by the perfusion of the cheek mucosa by the perforators deriving from the facial artery.

We have reported on a map of the six areas perfused by the mucosal perforators of the facial artery. The most reliable are the anterior and medial areas. The total stained area of oral mucosa perfused by the perforasomes from the facial artery describes a triangular-shaped area that could be selected to design made-to-measure flaps.

Our study demonstrates that it is possible to make flaps based on the mucosal perforators from the facial artery, and our data may also help to improve the harvesting of flaps based on the facial artery.

DEFINITION OF NEW TERMS

In view of the absence of references in the literature, we propose the concept of the "mucosal perforasome", a unique vascular territory perfused by a perforator artery in the mucosa. This concept may be useful because it allows a clearer understanding of the blood supply of the areas of mucosa in general; it can guide the creation of flaps of this kind and can differentiate them clearly from perforator flaps described in the skin.

To our knowledge, there are no descriptions in medical literature of “mucosal perforator”. We believe the determination of this concept may be useful, because it allows a clearer understanding of the blood supply of the areas of mucosa in general.

This information should be valuable in the harvesting of any flap based on the mucosal perforators of the facial artery, and in improving the making of currently used flaps. Our interest is specially aimed towards the reconstruction of nasal septal defects caused by inhalation of cocaine.

CLINICAL USE IN SEPTAL PERFORATION SECONDARY TO COCAINE ABUSE.

Many types of local flap have been described for reconstruction of the nasal septum (66,67), including oral mucosa flaps based on the vascular network from the deep ascendant branches of the labial artery and orbicular muscle. However, they only cover small periorificial defects (68).

Regional flaps are an option amongst others: Pribaz with the FAMM (14) and Zhao with the the buccinator island flap. (16) With our descriptions we can select the areas with the best vascularization corresponding to the anterior perforasomes of the oral mucosa, which are perfused by the mucosal perforators of the facial artery. These well-vascularized areas are optimal for the reconstruction of a septal defect, because they comprise mucosa, the flap is relatively thin, and their perfusion is well determined; they are especially useful in situations where the vascularity of the area has been chronically damaged, as in septal perforation due to cocaine use. This procedure guarantees an excellent result, always provided that the patient

gives up his/her cocaine habit. With the description of those areas or “mucosal perforasomes” we could harvest those optimal well-vascularized territories for reconstructing a septal defect, and/or another defect in the oro-nasal region.

OTHER POSSIBLE CLINICAL USES

Our findings may stimulate the search for similar mucosal areas elsewhere in the body. The observation of specific areas in the mouth may be replicated in other sites where reconstruction of the mucosa lining is needed, following the principle of "like with like tissue". This may well improve the quality of the reconstructions and reduce the need for harvesting of distant tissues.

These flaps have smaller caliber perforators than their counterparts in the skin, at least in the area of the mouth. It remains to be determined whether in other areas of the body the same configuration exists, or possibly even one that is more favorable from the surgical viewpoint. The identification of these areas may be extremely useful in the reconstruction of intestinal, genitourinary, and genital mucosa.

CONCLUSIONS

1. The oral mucosa of the cheek has direct perforators arising from the facial artery.
2. The majority of the facial artery perforators for the oral mucosa of the cheek, are located between the branching-off point of the superior and inferior labial artery.
3. The oral mucosa presents well-defined territories, each mainly perfused by a single perforator, which we term "mucosal perforasomes". Here we present a definition of the term.
4. We describe a map of the six areas perfused by the mucosal perforators of the FA. The most reliable are the anterior and medial areas.
5. The total stained area of oral mucosa perfused by the perforasomes from the FA describes a triangular-shaped area that could be selected to design made-to-measure flaps.
6. Our identification of mucosal perforators deriving from the facial artery has allowed us to design a well-vascularized flap for the reconstruction of defects in the nasal septum. We believe that this flap is very useful especially in situations where the vascularity of the area has been chronically damaged.
7. We think that our findings shed new light on the perfusion of mucosas and may be applicable to other areas of the body. They may also have implications for the use of mucosal flaps in reconstructive surgery.
8. Our findings have been used to support new advances in the field of oral reconstruction. (70).

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To all my family here and in the heavens.

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Mucosal perforators from the facial artery

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Abstract

The cutaneous perforators of the facial artery have been well described, but to our knowledge the oral mucosal perforators have not. We studied 10 facial arteries from 10 hemifaces in 5 cadavers. The arteries were injected with latex, and we studied all perforators that extended from the facial artery and headed directly to the oral mucosa. The diameter and length of the facial artery and its mucosal perforators were measured and compared. We found 52 oral mucosal perforators in the 10 facial arteries injected with latex. Their mean (SD) diameter was 0.5 (0.2) mm and the mean (SD) number/facial artery was 5.2 (1.1). Their mean (SD) length was 16.4 (5.3) mm. Most of those to the cheek were localised between the branching-off points of the inferior and superior labial arteries. The facial artery has perforators to the oral mucosa of the cheek, most of them between the points at which the labial arteries emerge.

Keywords: Facial artery; Mucosal perforators; Oral mucosa

Introduction

The reconstruction of the oral mucosa is an area of interest to facial surgeons. Techniques have evolved considerably since the introduction of perforator flaps,[1] which have been described in detail in recent years.[2–4] The development of perforator flaps allows single-stage operations and the use of made-to-measure flaps.

Even though we suspect the existence of perforators in the oral mucosa, we need to prove their existence. The classic description of facial artery perforator flaps by Hofer et al. was limited to perforators that lead to the skin.[5]

The objective of this study was to identify the facial artery perforators in the oral mucosa of the cheek, and to find out how many there are, their diameter and length, and their distribution in relation to the facial artery. This information is relevant to the harvesting of flaps based on the mucosal perforators of the facial artery, and to the harvesting of the flaps that are already in routine use.

Material and methods

Five heads of fresh-frozen cadavers were used, with 10 hemifaces that were dissected. The perforators in the oral mucosa of the cheek that extended from the facial artery (previously injected with latex) were identified. A

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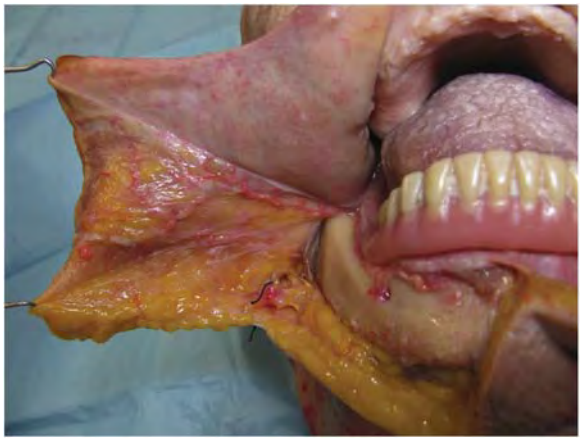

Fig. 1. Midline incision in the chin, oral mucosa incision, and raising of the cheek flap. Note the origin of the facial artery at the base of the jaw marked with a silk suture.

submandibular incision was made 2 cm below the lower edge of the jaw, and the facial artery and vein were identified at the level of their branching-off points below the edge of the jaw.

Injection of latex

The arteries were washed out with saline 30 ml, and two incisions made at the nasal philtrum to verify fluid outflow. Roughly 4 ml of diluted LME/R1 latex (Latex Compound Spanish SA Sabadell) was injected, until it was seen to flow out through the nasal incisions. The excess was removed and the samples frozen at −13 °C for 24 h.

An incision was made in the midline of the lower lip and chin. A flap was lifted in the oral mucosa at the level of the gingival sulcus that included the periosteum and reached the sphenomandibular ligament (Fig. 1). The dissection was submucosal to show the perforators that extended from the facial artery to perfuse the oral mucosa (Fig. 2).

Fig. 2. Red latex specimen. Exposure of facial artery and the mucosal perforators. The mucosal perforators (mp) can be seen between the points at which the superior and inferior labial arteries emerge (black arrows).

Descriptive anatomy

The facial artery was identified at its exit point from the mandibular branch. The dissection proceeded in an antegrade fashion from the artery to the mucosa up to its anastomosis with the angular artery. The diameter of the artery was measured at the base of the jaw. Dissection was continued to identify and preserve the oral mucosal perforators, and their origin over the facial artery, taking the base of the jaw as reference (Fig. 2). The perforators from the upper and lower labial arteries were not examined.

Measurements

We used the Image J software version 1.45s was used (W. S. Rasband, ImageJ, U.S. National Institutes of Health, Bethesda, MD, http://rsb.info.nih.gov/ij). The measurements were made on two photographs taken 30 cm away from the specimen. After it had obtained the scale and the conversion rate, the program converted the measurements into the distances recorded.

Statistical analysis

We used the STATA program version 11.1 (Lakeway Drive, Texas, USA). To assess the normality of the distribution of the variables we applied the Shapiro Wilk test, and to assess the normality of the variables we applied the normal probability plot technique. When the distribution of the variables was normal, we used the Spearman's R Correlation test to assess the significance of differences. When the distribution was not normal, the significance was assessed using Spearman's rank correlation coefficient. Probabilities of less than 0.05 were accepted as significant.

Results

Details of the measurements are given in Table 1. The distribution of the mucosal perforators from the facial artery shows that most of them were about 4–8 cm from the base of the jaw (Fig. 3).

Most of the mucosa of the cheek was reached directly by perforators from the facial artery. The mucosa of the lips was reached by perforators from the labial arteries, although these arteries were not the subject of our study. The superior labial artery was found in all cases. In two cases, the inferior labial artery was not found; in both these cases, the sublabial artery was identified.

Statistical analysis

There was a significant inverse correlation between the position of the mucosal perforator over the facial artery from the lower edge of the jaw and the length of the perforator ($p = 0.028$) (Fig. 4).

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Table 1
Measurements (diameter and length) of the facial artery and mucosal perforators (mm). Data are mean (SD) unless otherwise stated.

Dissection No.	Diameter	Total length of facial artery	No. of mucosal perforators	Diameter	Length
1	2.0	122.1	4	0.6 (0.2)	20.3 (2.5)
2	2.6	108.0	6	0.4 (0.1)	18.5 (7.4)
3	2.3	98.9	7	0.5 (0.2)	11.5 (1.5)
4	2.0	105.5	4	0.4 (0.2)	21.7 (3.9)
5	2.5	130.3	5	0.6 (0.1)	20.1 (2.7)
6	2.3	117.5	7	0.5 (0.1)	10.8 (5.0)
7	2.4	134.8	5	0.5 (0.1)	17.6 (1.9)
8	2.8	115.9	4	0.5 (0.1)	14.8 (3.9)
9	2.9	125.7	5	0.6 (0.1)	16.1 (1.8)
10	2.8	134.3	5	0.5 (0.3)	18.2 (6.3)
Mean (SD)	2.5 (0.3)	119.3 (12.4)	5.2 (1.1)	0.5 (0.2)	16.4 (5.3)

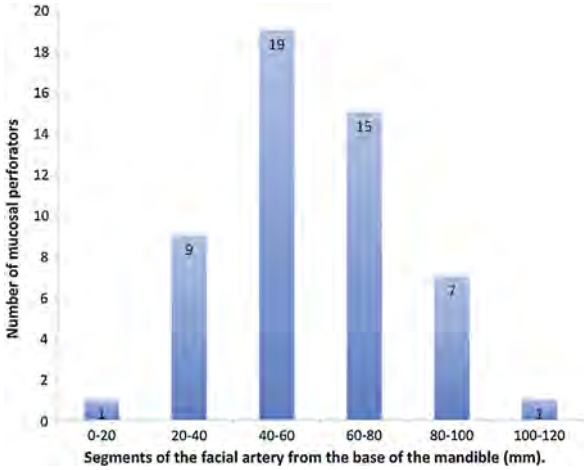

Fig. 3. Distribution of the mucosal perforators over the facial artery. The columns indicate the number of mucosal perforators that we found ($n = 52$) in consecutive segments of 2 cm from the base of the jaw.

There were no significant correlations between the diameter and length of the facial artery or the number of perforators, nor were there any significant correlations between the length and diameter of the mucosal perforators, or between the position of the perforator over the facial artery or its diameter.

Discussion

To date the study of facial perforators has focused on those that terminate in the skin.[5] In this study we have shown that there are also perforators that terminate in the oral mucosa. These are slightly lower, narrower, and shorter than their cutaneous counterparts.[6,7] The latex injection technique remains useful for identifying the perforator vessels from an artery.[8,9] We diluted the latex so that we could reach the small perforators from the facial artery.

Whetzel and Saunders[10] proposed that the primary arterial perfusion of the oral mucosa of the cheek was provided by the buccal and labial arteries. Our data show that the oral mucosa is also reached by perforators of the facial artery. We found most of them after the branching-off point from the inferior labial artery and before the exit point of the superior labial artery. We should not therefore dissect beyond the superior labial artery or the inferior labial artery (depending on the design of our flap) when we want to ensure the perfusion of a flap based on the mucosa of the cheek. The labial arteries provide similar perforators for the labial mucosa, and can be harvested when oral mucosa is needed.

We found a significant correlation between the origin of the mucosal perforator above the facial artery and the length of the mucosal perforator. That is, the perforators nearest the

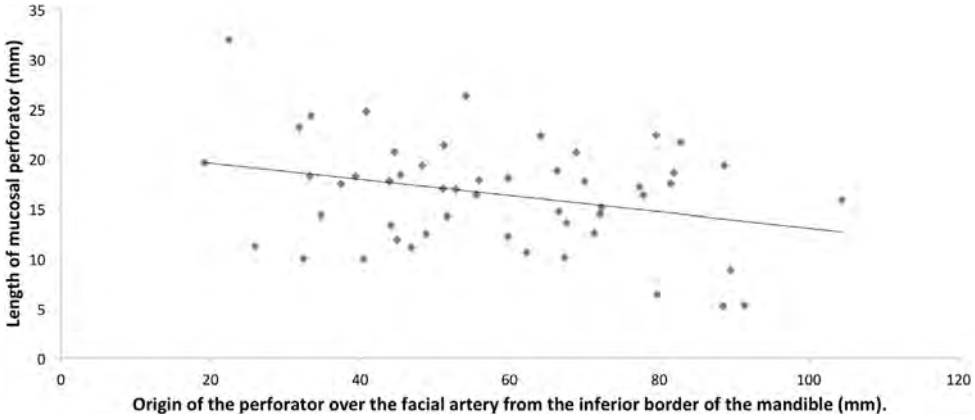

Fig. 4. Relation between the position of the mucosal perforator over the facial artery (FA) from the lower edge of the jaw and the length of the mucosal perforator ($p = 0.028$).

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branching-off site of the superior labial artery were not as long as the perforator next to the base of the mandible. This finding is relevant to the selection of the proximal perforators when a longer pedicle is needed. In future work it would be interesting to find out if this difference affects the areas perfused by the mucosal perforators.

Ng et al.[7] described a reference point from which to find cutaneous facial artery perforators. The possibility of using colour Doppler techniques to find out if the perforators are from the facial artery has already been proposed.[2,11,12] CT allows characterisation of the facial artery,[13] but these techniques are of little use in vessels with a calibre of less than 1 mm.[14] We found that most perforators branch between the site of the superior labial artery and the inferior labial artery or sublabial artery. These data suggest a landmark based on the emergence of the labial arteries for the localisation of mucosal perforators from the facial artery.

Pribaz et al.[15,16] described the FAMM flap for reconstruction of the oral mucosa based on the facial artery. Matros et al.[17] reported a technique for placing the pedicle in patients with intact dentition to avoid two-stage reconstruction. Zhao et al.[18] described the buccinator myomucosal island flap for harvesting mucosa from the same zone for diverse reconstructions of the oral cavity and beyond. All these techniques eventually use perforators from the facial artery.

A thorough knowledge of vascular anatomy is crucial to the understanding and designing of perforator flaps, and many studies have been published recently.[19–21] These perforator flaps allow primary closure of a defect and, more importantly, the use of the reconstructive principle of replacing tissues like-with-like.

The concept of the mucosal perforator flap is not standardised: at present, the only variables included in all definitions are the skin or subcutaneous tissue, or both.[22–25] We have shown that it is possible to make flaps based on the mucosal perforators from the facial artery, and our data may also help to improve the harvesting of flaps based on the facial artery and on its mucosal perforators.

Conflict of interest

The authors have no financial interests in this research project or in any of the techniques or equipment used in this study.

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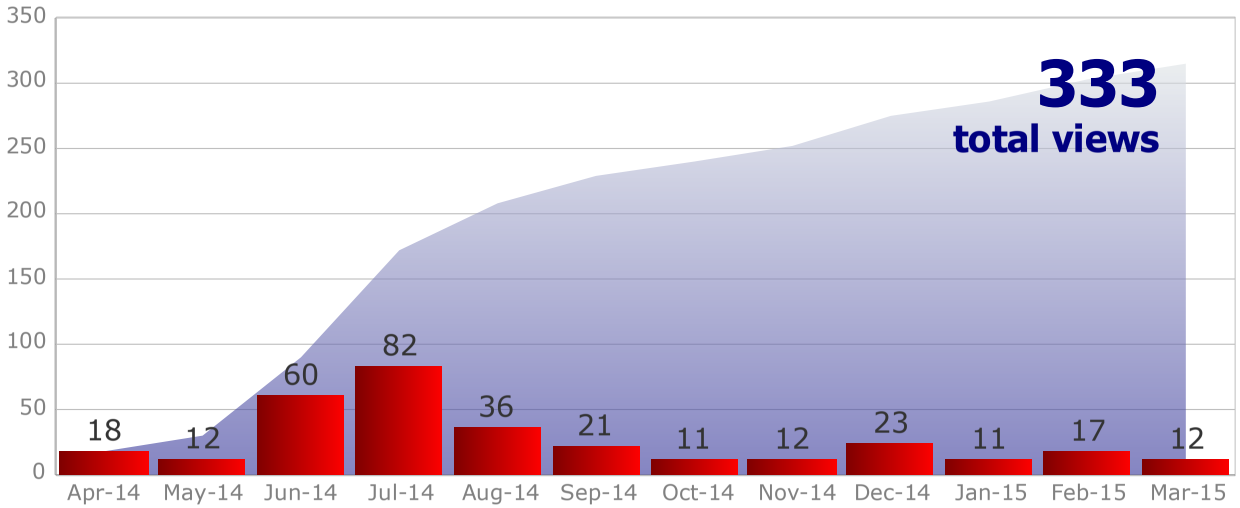

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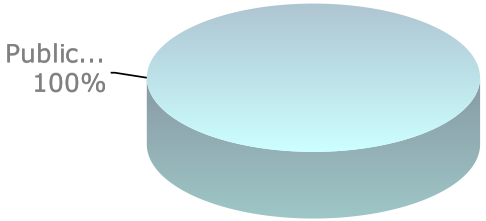

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Research Paper
Reconstructive Surgery

Cheek mucosa territories perfused by perforators from the facial artery

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Abstract. The cutaneous areas perfused by the cutaneous perforators of the facial artery have been well defined. However, the oral mucosal areas perfused by perforators of the facial artery have not been described. We studied 20 hemifaces from 10 cadavers. Perforators between the branching off sites of the labial arteries larger than 0.5 mm were selected and their diameters were measured; the distance between their exit point over the facial artery and the branching-off point from the superior labial artery was also measured. The selected perforators were injected with 1 ml of diluted ink. Both labial arteries were ligated to limit the study to the mucosal perforators from the facial artery. Seventy-four perforators from 20 hemifaces were studied; the mean diameter was 0.58 mm and the mean number per artery was 3.7. The total stained area, a triangle-shaped zone on the cheek, was determined. The more constant perforators larger than 0.5 mm were localized next to the branching-off site of the superior labial artery. With this information, flaps based on the mucosal perforators from the facial artery could be designed.

Keywords: facial artery; mucosal perforasomes; oral mucosa; surgical flaps.

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The use of oral mucosal flaps from the internal side of the cheek area to reconstruct oral defects has been well described by many authors.[1–4] All these flaps are based on the facial artery and its branches. However, their vascular territories have not been established. Qassemyar et al.[5] have described the cutaneous territories perfused by perforators from the facial artery. However, the facial artery perforators of the oral mucosa and the intraoral mucosal territories dependent on these perforators have not been described.

The objective of this study was to describe the oral mucosal perforasomes deriving from the facial artery, and also to determine their number, location, the mean perfused area, and their distribution.

Materials and methods

Twenty hemifaces from 10 fresh-frozen cadavers were used. The skin incisions followed a facelift pattern. Two incisions were added, the first from a 'crow's foot' to the ipsilateral tragus, and the second from four finger widths below the horizontal branch of the jaw.

A supra-superficial musculoaponeurotic system (SMAS) dissection was performed and all superficial perforators that could be identified were ligated. The facial arteries were dissected from the base of the jaw up to the branching-off point from the upper labial artery. Oral mucosal perforators from the facial artery between the branching-off points of the superior and inferior labial arteries that were larger than 0.5 mm were selected (Fig. 1).

The superior labial artery (SLA) and the inferior labial artery (ILA) were ligated after identification. Their branching-off points were determined. The posterior buccal branch of the facial artery was also ligated.

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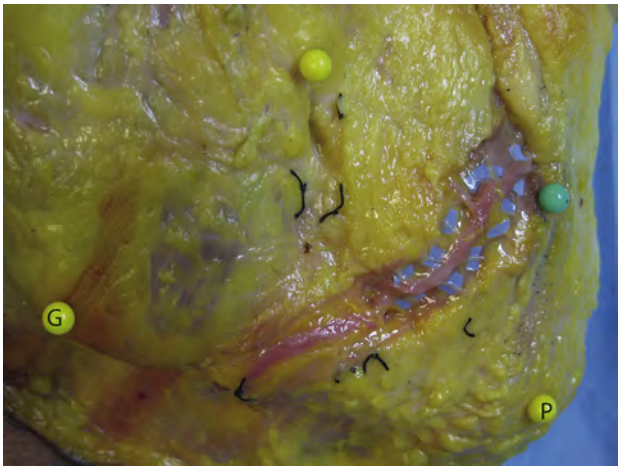

Fig. 1. Dissection of the facial artery tree and identification of its branches; several inserts beneath the facial artery perforators are shown (light blue). Note the guide points on the gonion (G) and pogonion (P). The site corresponding to the oral commissure is shown with a green guide point.

Descriptive anatomy

The length of the facial artery was measured from the lower edge of the jaw to the exit point of the SLA. The diameter of the facial artery was measured at the base of the jaw, the oral commissure, and the exit point of the SLA. The number of oral mucosal perforators was identified, as was their origin over the facial artery, taking the branching-off site of the SLA as a starting point.

Three landmark points were identified: the gonion, the pogonion, and the oral commissure. A line was traced between gonion and pogonion at the base of the jaw, and another parallel line starting from the oral commissure (Fig. 1).

Perforators larger than 0.5 mm were selected and perfused with 1 ml of diluted ink. After each injection, the presence of colour in the oral mucosa was examined. If colouring was observed, the area was identified and measured using the software ImageJ version 1.45s (Fig. 2).

Statistical analysis

Stata software program was used for the statistical analysis (StataCorp LP, College Station, TX, USA). The Shapiro–Wilk test and the normal probability plot technique were performed to assess the normality of the variables. If the distribution of the variables was normal, the Pearson's test was used. When distribution was non-normal, Spearman's rank correlation coefficient was used to evaluate the results.

To determine the branching-off sites of the SLA and ILA, the guide points described previously were used. Means, standard deviations, and 95% confidence intervals (CI) were calculated. Tolerance limits (TL) were also obtained with 95% confidence, such that 95% of the general population are within the limits determined.

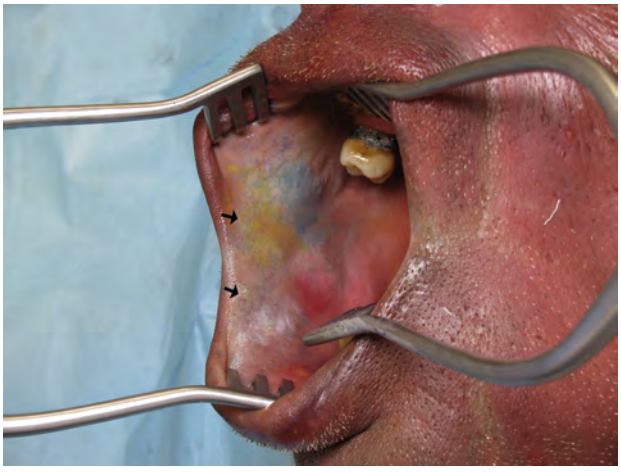

Fig. 2. Areas of the cheek stained by the mucosal perforators from the facial artery. Note the four perforasomes: two anterior (black arrows) and two middle.

Results

The mean length of the facial artery from the base of the jaw to the exit point of the SLA was 62.70 ± 6.18 mm. The diameter of the facial artery was 2.74 ± 0.38 mm at the base of the jaw, 1.76 ± 0.27 mm at the oral commissure, and 1.28 ± 0.24 mm at the bifurcation of the SLA. The mean number of perforators larger than 0.5 mm was 3.70 ± 1.22. In six cases we found a fifth oral mucosal perforator, and in one case a sixth (Table 1).

The SLA branched bilaterally from the facial artery in all cases. Taking the oral commissure as reference, the branching-off site of the SLA was identified 7.4 mm laterally and 5.1 mm above a line parallel to the lower edge of the jaw, between the gonion and pogonion. Using inferential statistics, we predicted the point of emergence of the upper labial artery within an area of 3 cm^2 in the general population (Table 2).

The ILA was present bilaterally in eight of 10 heads. In the other two cases, the sub-labial artery was identified. The mean point of emergence of the ILA was 9.60 mm above the lower edge of the jaw, on a line from the gonion to the pogonion, and 24.19 mm lateral to the oral commissure. Statistical tolerance limits were 3 cm in the first case and 5 cm in the second (Table 2).

Seventy-four perforators were measured. The mean diameter of the perforators at the branching-off site from the facial artery was 0.58 ± 0.19 mm. The 74 perforators were perfused and the mean area per perforator was 279.72 ± 156.24 mm^2. The perforators were measured from the branching-off site from the SLA, and only those larger than 0.5 mm were selected (Table 3).

The first two perforators were found in all cases. The first perforator was found at a mean distance of 4.51 ± 2.90 mm, and the second at a mean of 10.34 ± 4.19 mm. In 16 cases a third perforator was found at a mean of 16.65 ± 4.01 mm, in 11 cases a fourth was found at a mean of 23.10 ± 5.23 mm, in six cases a fifth was found at 31.74 ± 5.31 mm, and in one case a sixth was found at 40.92 mm.

The perfused areas in the oral mucosa were classified into six main types: three anterior areas near the oral commissure and the lips (superior, medial, and inferior), two middle areas (superior and inferi-

Table 1. General description of the facial artery.

Dissection number	Sex	FA diameter at the mandible (mm)	FA diameter at the oral commissure (mm)	FA diameter at the origin of the SLA (mm)	Length of the FA from mandible to SLA (mm)	Number of FAPM > 0.5 mm
1	M	2.30	1.90	0.90	62.30	2
2	M	2.98	1.50	1.25	52.20	2
3	M	3.65	1.71	1.37	59.05	2
4	M	2.74	1.91	0.98	57.93	5
5	M	2.44	1.61	1.25	63.98	6
6	M	2.55	1.90	1.11	64.58	5
7	M	2.51	1.62	1.23	63.30	5
8	M	2.71	1.68	0.96	64.96	3
9	F	2.86	1.64	1.20	66.22	3
10	F	2.23	1.76	1.10	61.71	3
11	F	2.24	1.56	0.97	65.23	5
12	F	2.51	1.59	1.28	74.77	3
13	F	2.73	2.03	1.35	60.72	3
14	F	2.50	1.85	1.70	58.98	4
15	M	3.06	1.71	1.67	65.19	4
16	M	2.62	1.63	1.59	74.87	4
17	F	3.51	2.68	1.58	67.43	4
18	F	2.67	1.87	1.49	64.27	5
19	F	2.96	1.61	1.27	49.56	4
20	F	3.03	1.42	1.39	56.82	2
Mean		2.74	1.76	1.28	62.70	3.70
SD		0.37	0.27	0.23	6.03	1.19

FA, facial artery; SLA, superior labial artery; FAPM, facial artery perforators of the oral mucosa; M, male; F, female; SD, standard deviation.

Table 2. Statistical analysis of measurements relative to guide points. Inferential statistics to determine the branching-off site of the superior labial artery and the inferior labial artery in the general population from our sample, with a 95% confidence interval.

Artery	Surface landmark		Number of dissections	Mean value (mm)	SD (mm)	95% CI $P < 0.05$	95% TL $P < 0.05$
Superior labial artery	Oral commissure	Lateral	20	7.40	±3.63	±1.70	±9.98
	Oral commissure[a]	Superior	20	5.12	±2.76	±1.29	±7.60
Inferior labial artery	Oral commissure	Lateral	20	24.19	±8.95	±4.19	±24.63
	Base of jaw	Superior	20	9.60	±5.46	±2.56	±15.04

SD, standard deviation; CI, confidence interval; TL, tolerance limits.
[a] A line parallel to the base of the jaw was used.

Table 3. Analysis of mucosal perforators in order of appearance. Distribution of the 74 areas found in the 20 dissected hemifaces and anatomical localization: three anterior zones, two middle zones, and one posterior zone.[a]

FAPM position	*n*	FAPM origin over the course of FA (mm)	Diameter (mm)	Anatomical localization				Coloured skin surface (mm^2)
1st	20	4.51 ± 2.90	0.52 ± 0.20	45.0%	Antero-superior	90%	Anterior zones	379.23 ± 182.55
				45.0%	Antero-medial			
				10.0%	Middle superior	10%	Middle zone	
2nd	20	10.34 ± 4.19	0.55 ± 0.21	35.0%	Antero-medial	65%	Anterior zones	305.83 ± 161.84
				30.0%	Antero-inferior			
				20.0%	Middle superior	30%	Middle zones	
				10.0%	Middle inferior			
				5.0%	Posterior			
3rd	16	16.65 ± 4.01	0.52 ± 0.19	25.0%	Antero-inferior	25%	Anterior zones	187.02 ± 73.25
				50.0%	Middle superior	69%	Middle zones	
				18.8%	Middle inferior			
				6.3%	Posterior	6%	Posterior zone	
4th	11	23.10 ± 5.23	0.49 ± 0.15	36.4%	Middle superior	82%	Middle zones	235.05 ± 99.77
				45.5%	Middle inferior			
				18.2%	Posterior	18%	Posterior zone	
5th	6	31.74 ± 5.31	0.49 ± 0.13	50.0%	Middle inferior			211.12 ± 105.58
				50.0%	Posterior			
6th	1	40.92		100.0%	Posterior			153.36
Total	74		0.53 ± 0.19					279.72 ± 156.24

FAPM, facial artery perforators of the oral mucosa; FA, facial artery.
[a] Measurement starting from the bifurcation of the superior labial artery. Results are expressed in millimetres as the mean ± standard deviation.

Fig. 3. Diagram of the oral mucosa perforasomes. The anterior area is divided into three areas, the middle area into two areas, and the posterior area is not divided. The total area of oral mucosa perfused is between the canines and a point halfway along a line between the second and the third upper and lower molars.

or), and one near the molars (posterior) (Fig. 3).

In most cases the first and second perforators perfused the anterior zone perforasomes (90% and 65%, respectively), whereas the third and fourth perfused the middle zone perforasomes (69% and 82%, respectively). The posterior perforasome had various origins (Table 3).

The total stained area corresponded to a triangle of oral mucosa located between the canines and a point halfway along a line between the second and third upper and lower molars (Fig. 3).

Statistical analysis

There was a statistically significant correlation between the diameter of the artery at the base of the jaw and at its branching-off point from the SLA ($P < 0.05$).

Spearman's rank correlation coefficient showed a significant inverse correlation between the distance from the exit point of the perforators starting at the branching-off point of the SLA and the stained areas of the oral mucosa ($P < 0.001$).

Discussion

A vascular territory nourished by a single perforator, or a 'perforasome', is a concept developed by Saint-Cyr et al.[6] This concept can help define precise territories for the creation of flaps for reconstruction.

In a previous work we characterized the perforators from the facial artery with latex.[7] In the present study we identified each perfused area or 'mucosal perforasome' with diluted ink. Likewise, we observed that the majority of perforators from the facial artery for the oral mucosa of the cheek were localized between the branching-off points of the SLA and the ILA.

Ng et al.[8] described a reference point for locating cutaneous facial artery perforators. In this study, in accordance with other reports, we used the emergence of the SLA as a landmark because of the reliability and consistency of its branching-off point.[9,10] We did not use the ILA as a landmark because of the greater variability of the artery, as described previously by Edizer et al.[11] The branching-off site of the ILA was less predictable. Statistically, the branching-off site may be found in an area of around 15 cm^2.

Using inferential statistics we were able to predict the branching-off site of the SLA in an area 2 cm long and 1.5 cm high with a surface area of 3 cm^2 for 95% of the general population. This method was reported by Whetzel and Mathes[12] for the description of certain perforators of the facial region and reproduces the previous findings of Nakajima et al.[9] and Pinar et al.[13]

The perfused areas coincided with the number of mucosal perforators found. After studying the 74 stained territories in all of the cadavers, it was clear that the perfusion was different in each cheek, and even in the same corpse. They were most consistently found in the anterior areas. The first pair of perforators perfused mainly the anterior perforasomes and the next two the medial perforasomes. This may be because, in the light of previous descriptions, it was decided to select only mucosal perforators larger than 0.5 mm.[14]

The mean area perfused by each perforator was 279.72 mm^2, notably lower than the cutaneous territories. The six areas of perfusion reproduce the pattern described in the skin[4] and are compatible with the perforasome theory of Saint-Cyr et al.[6] Similarly, we may assume that the perfusion of the posterior perforasome is provided by another source, probably the buccal artery or the anastomosis between the buccal artery and facial artery described by Zhao et al.[3]

In the case where only two or three perforators larger than 0.5 mm were found, the total stained area invariably reproduced the triangle-shaped zone between the canines and a point halfway along a line between the second and third upper and lower molars. All of the cheek mucosa inside that triangle could probably be elevated as a flap on these two or three perforators. The blood supply to the whole mucosa triangle would be provided by the direct and indirect linking vessels, as described for other perforator flaps.[15,16]

The arterial perfusion of the oral mucosa of the cheek has been described by Whetzel and Saunders.[17] They proposed that its primary perfusion was provided by the buccal and labial arteries. We have demonstrated that the oral mucosa is perfused directly by perforators of the facial artery.

The sum of all perforasomes corresponds to the area described previously by Whetzel, initially assigned to the labial arteries and buccal artery. In our cases we ligated them intentionally. The posterior perforasome probably shares perfusion with the buccal artery. This could explain the diverse sources of perfusion for the posterior territory.

The facial artery musculo-mucosal (FAMM) flap[1,4] is a very reliable and useful axial flap based on the facial artery. However, the maximum amount of mucosa that can be harvested has not been described. Landes et al.[2] have described the dorsally pedicled buccal musculo-mucosal (DPBM) flap and stated that this flap is supported by the submucosal plexus and, for that reason, a thin layer of buccinator is included to preserve that plexus. We could assume that the plexus is eventually supported by the musculo-mucosal perforators from the facial artery. Zhao et al.,[3] as a refinement of the flap described by Bozola et al.[18] and Carstens et al.,[19] described in detail the buccinator muscular mucosal system, and also described the arterial distribution of the buccinator muscle. However, they did not describe either the oral mucosal perforators of the facial artery or the areas they perfuse.

In this paper, we have described the maximum amount of mucosa that can be harvested to perform a reconstruction, reflected by the perfusion of the cheek mucosa by the perforators deriving from the facial artery. We have reported a map

of the six areas perfused by the mucosal perforators of the facial artery. The most reliable are the anterior and medial areas. The total stained area of oral mucosa perfused by the perforasomes from the facial artery describes a triangular-shaped area that could be selected to design made-to-measure flaps.

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Competing interests

The authors have no competing interests in this study.

Ethical approval

Ethical approval was not required by our institution.

Patient consent

Patient consent was not required in this study.

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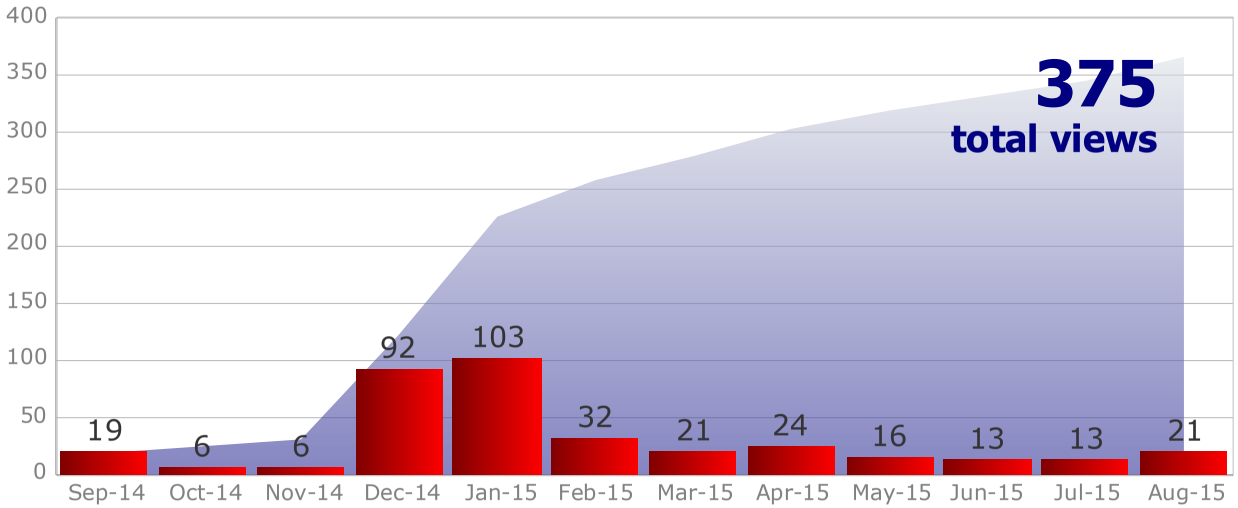

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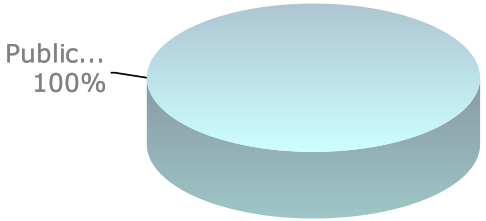

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Viewpoints

Mucosal Perforasomes

Sir:

The use of the term "perforator flap" is controversial.[1] According to the Ghent consensus study,[2] "a perforator flap is a flap consisting of skin and/or subcutaneous fat. The vessels that supply blood to the flap are isolated perforator(s). These perforators may pass either through or in between the deep tissues (mostly muscle)." The study also states that even if the skin is not included, the flap can be formed by Scarpa's fascia and subcutaneous fat. The current definitions of perforator flaps do not include the ones that terminate in the mucosa, only those that end in the skin.[3,4]

Fig. 1. Preparation with latex showing the facial artery perforator after crossing the muscle and reaching the oral mucosa.

Fig. 2. Blue latex preparation with several perforators between the emergence of the superior labial artery and the lower lip (*arrowheads*). The oral commissure is marked in *green*.

In our previous work,[5] we demonstrated the existence of direct perforators (Fig. 1) from the facial artery crossing through the muscle to reach the oral mucosa. These perforators irrigate specific mucosal territories, thus conforming to Saint-Cyr's definition of a perforasome.

We performed a systematic review of the literature through the PubMed database searching for articles with the keywords "perforator mucosa," "mucosal

perforator," "oral mucosa perforator," "oral mucosal perforator," "oral mucosa perforator flap," and "oral mucosal perforator flap." In all, 17 articles were identified.

In the same database, we searched for the keywords "perforasome" and "perforasomes"; in all, 16 articles were identified. We examined each of the references to see whether they described mucosal perforator flaps, mucosal perforators, or mucosal perforasomes. None of the references quoted in these articles mentioned mucosal perforators or their perforasomes.

Perforators are penetrating arteries that emerge from a main vessel, pass through the muscle or another anatomic structure, and reach the skin or subcutaneous tissue.[1–4] Perforators and perforasomes have been described in other areas, but none of the current definitions identify the mucosa as a final destination of a perforator artery.

In view of the absence of references in the literature, we propose the concept of the "mucosal perforasome," a unique vascular territory irrigated by a perforator artery in the mucosa. This concept may be useful because it allows a clearer understanding of the blood supply of the areas of mucosa in general; it can guide the creation of flaps of this kind and differentiates them clearly from perforator flaps described in the skin.

Our findings may stimulate the search for similar mucosal areas elsewhere in the body. The observation of specific areas in the mouth may be replicated in other sites where reconstruction of the mucosa lining is needed, following the principle of "like with like" tissue.

These flaps have smaller-caliber perforators than their counterparts in the skin, at least in the area of the mouth. It remains to be determined whether in other areas of the body the same configuration exists. The identification of these areas may be extremely useful in the reconstruction of intestinal, genitourinary, and genital mucosa.

The oral mucosa presents well-defined territories, each mainly irrigated by a single perforator (Fig. 2), which we term "mucosal perforasomes." In this article, we present a definition of the term.

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An Easy and Applicable Method for Capturing High-Quality Rhinoplasty Videos: Handle Banded Camcorder

Sir:

Intraoperative digital video recording is necessary for presenting your work, teaching, research, auditing, and patient education.[1] However, capturing high-quality video during rhinoplasty is challenging.[2] We describe an effective and practical recording method based on the use of a camcorder attached to a surgical light handle.

For recordings, we used a commercially available high-definition digital video camcorder (Sony HDR-CX115E HD Handycam Camcorder). First, the camera was put into a sterile plastic bag and the adjustable video screen was turned toward the surgeon. Then, the part of the bag covering the lens was cut with scissors. The covered camera was attached to the operating light handle using a sterile drape. The sterile light handle was then attached to the surgical light. This sterile and mobile camera system allows either an assistant or a gloved surgeon to adjust the camera's field of view without contamination (Fig. 1).

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It allows rapid manipulation and understanding of an individual's anatomy by physically holding the object and being able to visualize it in multiple planes. This can be useful for teaching learners, and can be used as a tool to better explain the proposed surgery to patients using their own anatomy.

One limitation of the process is the cost associated with production of the model, which can be anywhere from $400 to $1200. Also, due to the minuteness of perforator vessels, some smaller vessels do not endure the printing process due to the resolution limitations of the three-dimensional printer. This can be ameliorated with a larger model, albeit at a higher cost. Also, the materials used to make certain models are delicate, and rough handling can cause perforator branches to crack. However, postprinting processing with materials such as wax can create a durable model that can be used in clinics and teaching sessions.

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Reconstruction of Nasal Septal Perforations in Cocaine-Addicted Patients with Facial Artery Mucosa-Based Perforator Flap

Sir:

Septal perforation is one of the most frequent complications of snorting cocaine. A wide range of mucosal defects have been described, from a clinically asymptomatic state through pinpoint holes to the destruction of the dorsal support, or even the destruction of the maxilla.

Various types of local flaps have been tested for reconstruction of the nasal septum.[1] Because of the high risk of failure due to damage to adjacent tissue, the use of distant tissues or even distant free flaps is preferred.[2] The problem with remote or free flaps is that their volume may be excessive and they may obstruct the passage of air. Other authors have described useful mucosal regional flaps, such as the facial artery musculomucosal,[3] an axial flap centered over the facial artery, or the buccinator flap,[4] based on the posterior buccal artery or the anterior segment of the facial artery.

Anatomical studies performed by our group have identified direct perforators from the facial artery irrigating specific mucosal territories.[5] On the basis of these findings, we have designed an island flap by selecting the areas with the best vascularization, that is, the anterior and middle facial artery perforasomes of the oral mucosa. To our knowledge, this is the first description in the literature of a mucosa-based perforator flap.

Using Doppler sonography, we mark the path of the facial artery in the oral mucosa. We harvest the musculomucosal flap by extracting an area about 20 percent larger than the defect that we aim to cover.

We attempt to ligate the facial artery in the gingival sulcus, taking care not to damage the perforators next to the buccinator and orbicularis muscles. We perform a retrograde dissection of the facial artery, taking extreme caution at the branching-off site of the superior labial artery bifurcation. The exit point of the superior labial artery will be 7.4 ± 9.98 mm laterally and 5.1 ± 7.6 mm above the oral commissure in a line parallel to the lower edge of the jaw, between the gonion and pogonion (95 percent tolerance limits).[5] The area measures approximately 3 cm^2.

Once we reach the bifurcation of the superior labial artery, we ligate it and continue the dissection over the facial artery to the base of the nasal ala or to a point where we can easily insert our flap inside the nose (Fig. 1). On the septal orifice, we excise the borders of the defect until we find healthy tissue and attach our flap with strategically placed sutures (Fig. 2).

At this point, if required, we modify the nasal tip by open rhinoplasty. Similarly, if cartilage grafts are required for the nasal dorsum or grafts or local plasty to release the nostrils, reconstruction is performed.

These well-vascularized areas are optimal for reconstructing a septal defect, because they comprise

Fig. 1. Raised perforator flap.

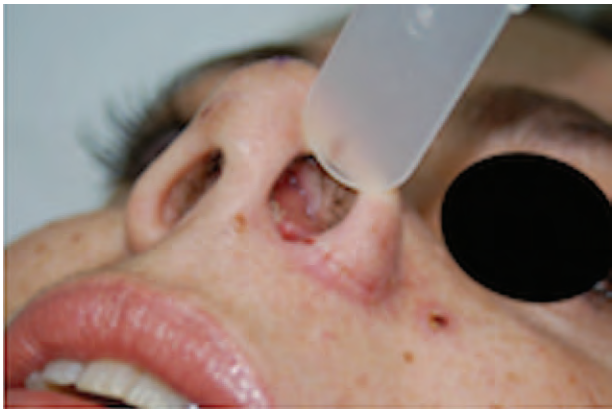

Fig. 2. Flap inserted in the opening in the septum.

mucosa, the flap is relatively thin, and their perfusion is well determined. This procedure guarantees an excellent result, provided that the patient gives up his or her cocaine habit.

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DISCLOSURE

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

PATIENT CONSENT

The patient provided written consent for the use of her images.

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Efficacy of the Buccal Fat Pad Graft in Facial Reconstruction and Aesthetic Augmentation

Sir:

Small facial soft-tissue contour deformities are usually corrected via the transfer of autogenous lipoaspirate, due to the small volumes and precision required. The popular use of lipoaspirate is not without complications, including volume resorption, difficulty in achieving a three-dimensional conformational shape, and the possibility of fat embolism.[1] The main reason for delayed absorption of aspirate is well known to be trauma during the aspiration procedure.

In this article, we introduce the free buccal fat pad graft as an alternative to correct these small-volume facial deformities. Because the fat structure is well preserved, it is able to maintain its volume and consistency. The anatomy of the buccal fat pad should be well understood, in order to minimize donor-site complications and ensure minimal damage to the fine lobular architecture of the fat pad.

The buccal fat pad graft is harvested via a single, intraoral buccal incision. The opening of Stenson's duct is identified, and the buccal incision is placed away from the duct orifice at the level of the mandibular occlusal line. The buccinator muscle is split using blunt dissection, and the encapsulated buccal fat pad is delivered, with external digital pressure. Care is taken to avoid damaging the capsule of the fat pad.

All 15 cases were performed by a single surgeon (Table 1). There were no donor-site complications. There were no cases of cheek contour deformity. All 15