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Where to find facial artery perforators: a reference point

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SUMMARY

Reconstructive surgery of the midface using facial artery perforator (FAP) flaps is being used more frequently now as it has been reported to provide better aesthetic results and reduce a traditional two-stage procedure to a one-stage technique. Wide acceptance of this approach is limited by poor understanding of the anatomy associated with this technique however. This was investigated through a cadaveric study. The facial artery (FA) of 16 cadaveric half faces were each identified, cannulated with coloured latex, and then dissected to give an accurate and quantified description of FA perforating branches. A lateral view picture of each specimen was taken and analysed using ImageJ 1.42q. Cadaveric dissections showed that each hemiface could be regarded as a single entity. Means: FA length = 116 ± 22 mm, FA diameter = 2.62 ± 0.74 mm, number of FAPs = 4 ± 2 , FAP length = 14.12 ± 3.46 mm, FAP diameter = 0.94 ± 0.29 mm. A reference point, A, where FAPs were consistently found to originate was also identified. Therefore, the FAP flap is a viable and valuable addition to plastic reconstructive techniques. The localisation of point A with precise measurements can facilitate the design and use of such FAP flaps for the reconstruction of nasal, as well as perinasal and perioral defects.

KEYWORDS: facial artery, perforator flap, facial reconstruction, cadaveric study

INTRODUCTION

The Reconstructive surgery of the midface due to infection, trauma, neoplasm, or congenital malformations, presents a unique surgical challenge. Cosmetic and functional considerations such as colour match and blood supply respectively, have led to local flaps based on the facial artery (FA) becoming the preferred method for such reconstructive work.

Fuelled by the knowledge that single perforators in other parts of the body have been shown to supply large areas of tissue¹, the concept of facial artery perforator (FAP) flaps was conceived and investigated in order to achieve a greater degree of freedom for reconstructive work. Most recently, the use of such flaps has facilitated the possibility of one-stage reconstruction instead of the traditional two- (or more) stage technique^{1, 2}. This has also been reported to provide a much better aesthetic result that is more appealing to the patient. A poor understanding of the number and distribution of the perforating branches of the FA however, limits wide acceptance of this approach⁸.

This study therefore aimed to investigate the anatomy associated with one-stage reconstruction of the midface using FAP flaps and to give an accurate and quantified description of FA perforating branches suitable for use in facial flaps.

METHODS

Cadaveric Study

Dissections were performed on 16 cadaveric half-faces. By incising vertically along a line anterior to the ear, from the base of the nose (nasofrontal angle) towards the ear along a line just inferior to the lower eyelid, and from the nasal ala base towards and along the mandible, a flap

was created in each hemiface. The overlying skin in the flap thus created was then carefully raised and separated from the underlying subcutaneous tissue and reflected medially. This was followed by identification of the FA after locating the submandibular gland. Coloured latex was then injected into the FA of each specimen and left to stand for an hour for adequate uptake and distribution to highlight all of its branches.

Using standard surgical instruments and loupes, the FA was traced in a caudocranial direction in each specimen to outline its general course according to a classification system modified from Nakajima et al (2002)³ (Figure 1). This was done in a highly meticulous manner using the ‘open cast’ technique⁴: scissors were used to advance along the path of the FA by gentle probing; subcutaneous tissue or muscle was cut only when further advancement was not possible. This was repeated to delineate individual perforating branches from the FA.

Computer Analysis

For the purpose of this study, only branches of the FA that travelled directly through subcutaneous tissue to the surface of the skin were considered as FAPs. Using ImageJ 1.42q (Rasband, W.S., ImageJ, U. S. National Institutes of Health, Bethesda, Maryland, USA, <http://rsb.info.nih.gov/ij>, 1997-2005), the following were measured from lateral view pictures of the specimens:

- The length of each individual FA from the anterior rim of the mandible to its termination within the nasolabial fold or, depending on its course, near the medial canthus (Figure 1)
- The number of FAPs
- The length traversed along the FA before each perforating branch
- The length of each perforator from its origin along the FA to the surface of the skin
- The range of diameter of the FA

- The diameter of FAPs at their origin on the FA

All measurements were done in triplicate. This allowed the extent and variation of the superficial blood supply from major FA branches to be described, and to allow for the influence of intra-observer variation. Inter-observer variation was not tested at this stage.

RESULTS

After determining the general course of the FA, the results of the measurements, performed as outlined in the previous section, were analysed (Tables 1 to 3). The mean total lengths of the FA and its perforators were 116 mm (range, 72 to 159 mm) and 14 mm (range, 6 to 19 mm) respectively. The corresponding mean diameters of the FA and that of its perforators were 2.62 mm (range, 1.45 to 4.19 mm) and 0.94 mm (range, 0.53 to 1.36 mm). In all specimens, multiple FAPs were noted along the course of the FA and there was a mean of four per hemiface (range, 2 to 8).

Each side of the face can be regarded as a single entity because the general course of the FA, the number of FAPs, the mean length and diameter of the FA and that of the perforators, differed between the right and left hemiface (Tables 2 and 3). However, in dissection number four on the right side of the face, the mean length of the FA was much shorter (Type D course of FA). Noticeably, this dissection's mean FA diameter was also smaller than that of other dissections. A type D course was also noted in dissection number eight on the right side of the face. In this specimen, the mean length and diameter of the FA did not differ much from other specimens. The mean length of FAPs in dissection number two was also much smaller than that of other dissections.

The number of perforators varied between each side of the face so their distribution along the length of the FA was plotted (Figure 2). The majority of FAPs originate between 20 and 60 mm along the length of the FA, corresponding to an area near the angle of the mouth. Beyond 60 mm, the number of perforators decreased and the distribution became inconsistent. In reality, the distribution of these perforators will be much more compact as the FA itself has a tortuous course.

A common origin of FAPs was identified. Termed point A, this can be located using a Frankfort horizontal line, a line parallel to the Frankfort plane running across the angle of the mouth, and a perpendicular line through these two lines at the lateral canthus (Figure 3). This enabled a second set of analysis to be performed (Table 4).

FAPs can most consistently be located (point A, Figure 3) at a mean acute angle of 45 degrees from the horizontal (range, 20 to 63 degrees), and at a mean distance of 10 mm (range, 4 to 24 mm) from point B (Figure 3). These results suggest that the use of the Frankfort line is crucial because horizontal lines uncorrected by this may lead to inaccurate placement of point A and cause damage when raising FAP flaps in this area. In one of the specimens however, point A was located at about thirteen degrees above the horizontal line where point B can be located (Table 4).

DISCUSSION

There are many reconstructive options for midface defects but the nasolabial flap and its many variations work well for nasal ala reconstruction and other facial defects^{1,2}. Recently however, the use of FAP flaps for such reconstructive work is becoming increasingly common^{2,6,8}. These flaps are all supplied by perforating branches from the FA¹. This change in paradigm stems from the landmark work by Taylor and Palmer (1987)⁵, and several institutions have reported highly satisfactory experiences in using such FAP flaps^{2,6}.

In this cadaveric study, the anatomy of the FA was investigated to delineate the extent and distribution of its branches for use in FAP flaps. According to the criteria set out by Lyons (2005), acceptable perforator flap donor sites in head and neck surgery have four common features: a predictable and consistent blood supply, at least one large perforator (diameter ≥ 0.5 mm), sufficient pedicle length for the procedure, and a donor site that can be closed primarily with the absence of excessive wound tension⁴.

Our results show that these criteria can be met for FAP flaps. Firstly, the variation in distribution and calibre of FAPs was independent of the path traversed by the FA. This is commensurate with the findings by Hofer et al (2005)¹. However, the poor and inconsistent distribution of perforators beyond 60 mm along the course of the FA is recognised. This suggests that the area might not be as good a site for the raising of flaps for reconstruction. Analysis also showed that perforators could most consistently be found between 20 and 60 mm along the course of the FA. This facilitated the definition of a reference point A (Figure 3) for the identification of these perforators. Secondly, the mean diameter of FAPs in the dissections was greater than 0.5 mm and there were at least two such perforators in each specimen. Thirdly, the length of FAPs was sufficiently long to allow local movement without excessive “kinking” or torsion. Lastly, the location of point, A, within proximity of the nasolabial fold, allows flaps to be raised with more confidence while at the same time, allowing surgical scars to be placed within or parallel to the fold and achieve good cosmesis.

We note that our results (mean FAP length = 14.1 mm) differ from that reported by Hofer et al (2005)¹ (mean FAP length = 25.2 mm). We do not have an explanation for this but there are three possibilities: our study was performed on embalmed cadavers that may have altered the subcutaneous position of the vessels but we doubt that this was of any significance; FAP length

may vary with race and body mass index and this raises several questions that would make for further, interesting studies; both this study and that of Hofer et al (2005)¹ used small sample sizes that are not representative of a larger population and we believe this to be the most likely cause of the variation between the results.

To our knowledge, an accurate reference to locate FAPs has not been previously described. These results suggest a single point, point A, can be readily identified (Figure 3). The use of a handheld Doppler ultrasonography probe might be of value to ascertain whether there actually are any perforators at point A but at present, the literature as to whether ultrasound can distinguish such perforators from the FA itself with confidence is not definitive^{2,4-7}. After locating point A, an exploratory incision along either margin of a pre-operatively designed nasolabial flap will facilitate the raising of such FAP flaps. While this study's results show that the distribution of perforators near the base of the nasal ala to be inconsistent, D'Arpa et al (2009)² have shown that to be otherwise. As such, the perforator at point A could either serve as the pedicle of the flap itself or aid further exploration for the availability of perforators near the ala base (Figure 4). This incision can always be closed primarily and placed within proximity of the nasolabial fold to minimise any adverse scarring.

While the use of free style perforator flaps is gaining in popularity, the current literature about the size of such flaps that can be raised is not clear. It is well recognised though that the area of skin supplied has an inverse relationship with the number of perforators in that area⁸. Therefore, the angiosome⁵ of the perforator(s) at point A was investigated. However, this was technically very demanding in a cadaveric study. Although this particular perforator could be located and cannulated without prior injection of the FA with latex, the uptake of the perforator was not satisfactory and its area of distribution on the skin could not be determined with confidence. Nevertheless, survival of FAP flaps up to 2.5 by 5 cm has been reported¹, suggesting that

perfusion may not be a key indicator. This methodology of investigation was not continued in this study but further investigations may be undertaken to pursue this more precisely.

There are several limitations to this study. Although of great importance, the venous drainage of the FAP flap was not investigated as the current cadaveric model did not suitably maintain venous integrity. Further studies may include this with cadaveric models that facilitate venous investigation. The results have not as yet been applied in a case series. However, it is hoped that a reasonable number of cases would be performed and for such a case series to be reported. It would also be interesting to see the results of a similar study done on fresh-embalmed and soft-embalmed cadavers due to difference in the mobility of tissues.

CONCLUSION

This study has shown that FAP flaps are a viable and valuable addition to the repertoire of reconstructive techniques available to the plastic surgeon. The identification of a reference point, point A, offers the advantage of a very high possibility of locating perforators for raising flaps at the nasolabial fold and which also can serve as an aesthetically pleasing donor site. The angiosome⁵ of the perforator at point A, and indeed, any other constantly occurring FAP, requires further investigation that may provide better understanding of the boundaries of vasculature of such free style flaps.

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CONFLICT OF INTEREST STATEMENT

None.

REFERENCES

1. Hofer SO, Posch NA, Smit X. The facial artery perforator flap for reconstruction of perioral defects. *Plast Reconstr Surg* 2005; 115: 996–1003.
2. D'Arpa S, Cordova A, Pirrello R, Moschella F. Free style facial artery perforator flap for one stage reconstruction of the nasal ala. *J Plast Reconstr Aesthet Surg* 2009; 62: 36–42.
3. Nakajima H, Imanishi N, Aiso S. Facial artery in the upper lip and nose: anatomy and a clinical application. *Plast Reconstr Surg* 2002; 109: 855–61.
4. Lyons AJ. Perforator flaps in head and neck surgery. *Int J Oral Maxillofac Surg* 2006; 35: 199–207.
5. Taylor GI, Palmer J. The vascular territories (angiosomes) of the body: experimental study and clinical applications. *Br J Plast Surg* 1987; 40: 113–41.
6. Demirseren ME, Afandiyev K, Ceran C. Reconstruction of the perioral and perinasal defects with facial artery perforator flaps. *J Plast Reconstr Aesthet Surg* Article in Press DOI: 10.1016/j.bjps.2008.07.037
7. Taylor GI, Doyle M, McCarten G. The Doppler probe for planning flaps: anatomical study and clinical applications. *Br J Plast Surg* 1990; 43: 1–16.
8. Hofer SO. Comment to “Free-style local perforator flaps: concept and classification system.” *J Plast Reconstr Aesthet Surg* 2009; 62: 609.

Figure 1. Four types of major-branch distribution of the facial artery (FA): types A, B and C (after Nakajima et al (2002)), and type D (noted in two dissections) – the FA terminated as the superior labial artery; instead of an angular artery, the supratrochlear artery supplied the area within the nasolabial fold.

Figure 2. Number of facial artery perforators along the course of the facial artery in dissections.

Figure 3. In addition to the Frankfort horizontal line, a parallel line at a level that passes through the angle of the mouth is also drawn. A perpendicular line is then drawn from the lateral canthus to pass through these two lines. Point B represents the intersection of the parallel line through the angle of the mouth and the perpendicular. Point A represents the reference point to locate the area where facial artery perforators can be found to originate most consistently.

Figure 4. Design of facial artery perforator flaps using point A, which can serve as the pedicle itself or aid exploration for other perforators.

Table 1. Summary of analysis of all measurements performed on specimens. FA = facial artery; FAP = facial artery perforators.

Table 2. Mean length of the FA and its perforators in each specimen. Number before R or L refers to individual specimen number; letters in parentheses represent course of FA according to Figure 1. FA = facial artery, FAP = facial artery perforator; R = right, L = left.

Table 3. Mean diameter of FAPs. The number after the letter (e.g. 3 in 1R(A),3) refers to the number of FAPs in that particular specimen. FAP = facial artery perforator.

Table 4. Measurements of the angle and distance from point B to point A where FAPs can most consistently be found in all dissections (Figure 4). FAP = facial artery perforator. # In this specimen, the FAP was located above both point A and the parallel line along which point B is formed (Figure 4).

Figure 1 Four types of major-branch distribution of the facial artery (FA): types A, B and C (after Nakajima et al (2002)), and type D (noted in two dissections) - the FA terminated as the superior labial artery; instead of an angular artery, the supratrochlear artery supplied the area within the nasolabial fold.

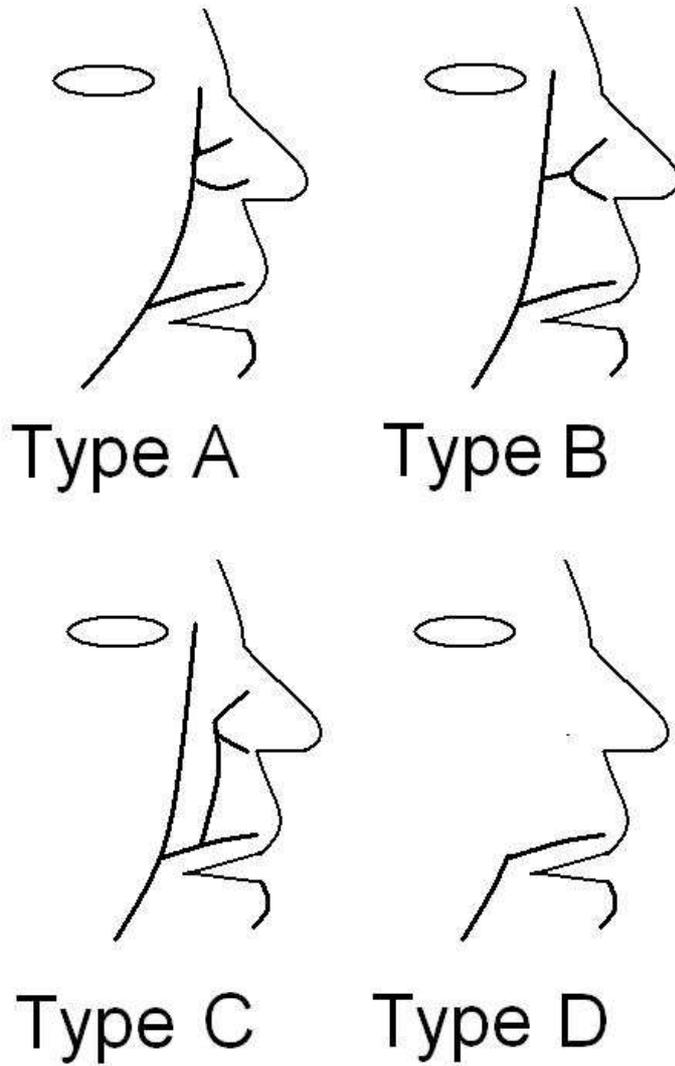


Table 1 Summary of analysis of all measurements performed on specimens. FA = facial artery; FAP = facial artery perforators.

MEASUREMENT	MEAN ± SD
FA Length	116 ± 22 mm
FA Diameter	2.62 ± 0.74 mm
Number of FAPs per hemiface	4 ± 2
FAP Length	14.12 ± 3.46 mm
FAP Diameter	0.94 ± 0.29 mm
Angle from point B to point A (Figure 3)	46.26 ± 19.71°
Length from point B to point A (Figure 3)	9.94 ± 4.90 mm

Table 2 Mean length of the FA and its perforators in each specimen. Number before R or L refers to individual specimen number; letters in parentheses represent course of FA according to Figure 1. FA = facial artery, FAP = facial artery perforator; R = right, L = left.

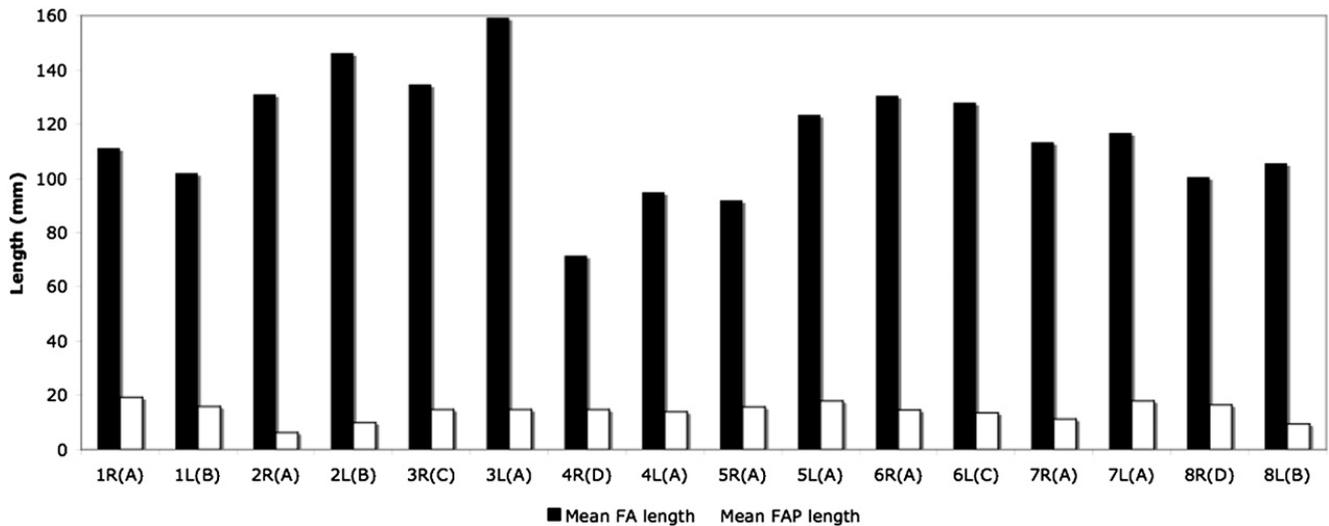


Table 3 Mean diameter of FAPs. The number after the letter (e.g. 3 in 1R(A),3) refers to the number of FAPs in that particular specimen. FAP = facial artery perforator.

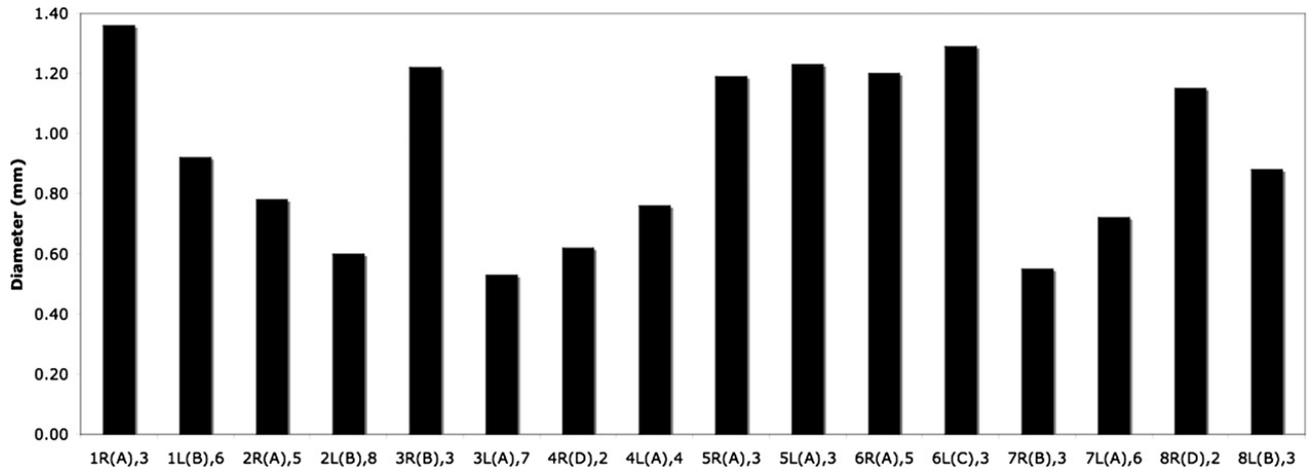


Figure 2 Number of facial artery perforators along the course of the facial artery in dissections.

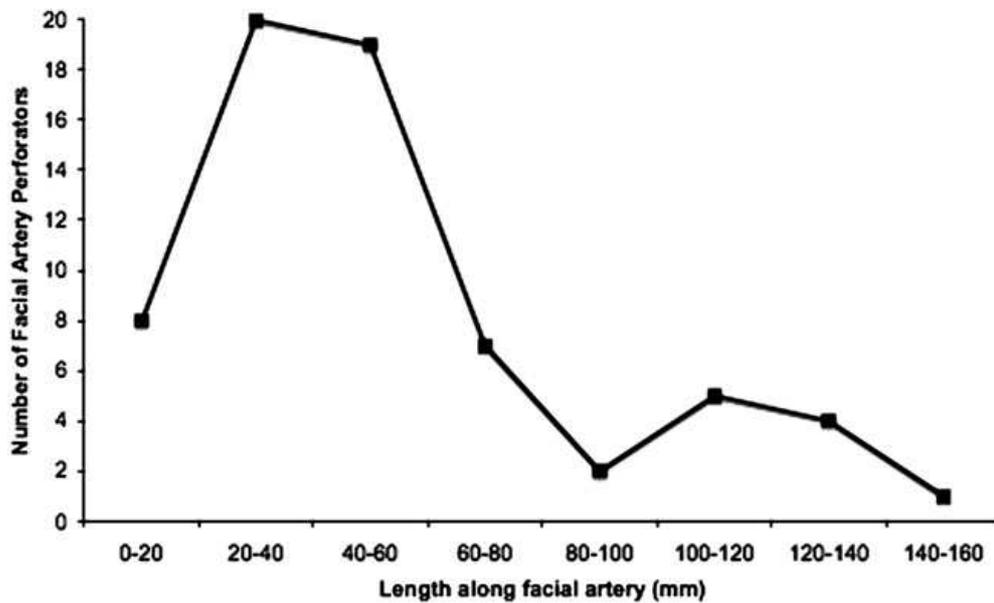


Figure 3 In addition to the Frankfort horizontal line, a parallel line at a level that passes through the angle of the mouth is also drawn. A perpendicular line is then drawn from the lateral canthus to pass through these two lines. Point B represents the intersection of the parallel line through the angle of the mouth and the perpendicular. Point A represents the reference point to locate the area where facial artery perforators can be found to originate most consistently.

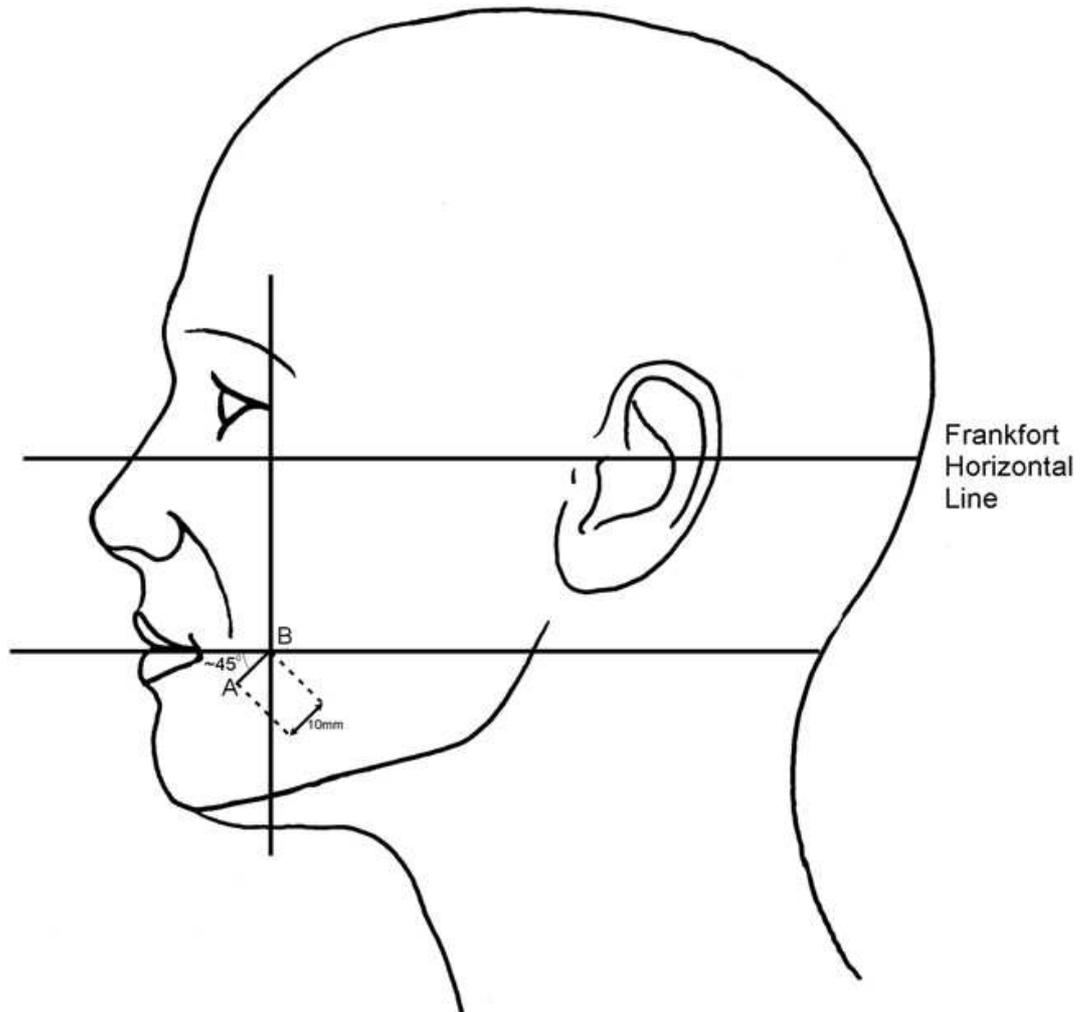


Table 4 Measurements of the angle and distance from point B to point A where FAPs can most consistently be found in all dissections (Figure 4). FAP = facial artery perforator. In specimen 8L, the FAP was located above both point A and the parallel line along which point B is formed (Figure 4).

Specimen No.	Side	FA Course	Mean acute angle (°)	Mean distance (mm)
1	R	A	46.12	8.94
1	L	B	59.26	9.95
2	R	A	58.30	7.98
2	L	B	28.14	23.64
3	R	B	45.52	15.24
3	L	A	62.91	6.20
4	R	D	62.40	8.02
4	L	A	49.08	4.35
5	R	A	35.88	7.35
5	L	A	41.10	7.39
6	R	A	20.14	11.61
6	L	C	57.61	5.44
7	R	B	57.57	5.88
7	L	A	49.94	14.84
8	R	D	52.88	8.73
8	L	B	-13.37#	13.44
Mean ± SD	-	-	46.26 ± 19.71	9.94 ± 4.90

Figure 4 Design of facial artery perforator flaps using point A, which can serve as the pedicle itself or aid exploration for other perforators.

