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Clinical significance of buccal branches of the facial nerve and their relationship with the emergence of Stensen's duct: An anatomical study on adult Taiwanese cadavers

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ABSTRACT

Objective: This observational study on adult Taiwanese cadavers focused mainly on the intersection of buccal branches of the facial nerve with Stensen's duct, using the emergence of Stensen's duct as the reference landmark.

Materials and methods: Thirty-five cadaveric hemifaces were included in our research. Samples with facial defects due to tumor, trauma, or surgery were all excluded. Buccal branches of the facial nerve were identified according to the Gray's Anatomy 40th edition definition. The distance was measured from the intersection to the emergence of Stensen's duct, running from the anterior border of the parotid gland.

Results: In the 35 hemifaces, the number of buccal branch/Stensen's duct intersections ranged from 1 to 5 (average 2.49 ± 1.15). Two-point intersections accounted for 37% (13 hemifaces) of the sample, forming the largest group. Samples of facial nerve buccal branches were divided into four types: Type 1, with two buccal branches, accounted for 37.15% (13/35); Type 2, with three buccal branches, made up 48.59% (17/35) of our samples — the biggest group (Type 2-a was the most frequent pattern among our samples, with two superior buccal branches and one inferior buccal branch, accounting for 34.31% of our samples); Type 3, with four buccal branches, accounted for only 5.7%. Three cases of double Stensen's duct were classified as Type 4, though this is supposed to be a very rare anatomical variation. With Type 2a, the most frequent pattern among our specimens, the distance from the emergence of the Stensen's duct to the emergence point of the first superior buccal branch along the anterior border of the parotid gland was 9.58 ± 5.68 mm. The distance from the emergence point to the emergence of the inferior buccal branch along the anterior border of the parotid gland was 11.03 ± 5.38 mm. The distance (D1) from Stensen's duct to the emergence of the first superiorly located buccal branch of the group Type 2-a was statistically different from the distance (D1) of the other groups ($p = 0.02$). No direct anastomoses or communicating fibers between upper and lower buccal branches were noted in 11 hemifaces (31%).

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Conclusion: The distribution of buccal branches was described using the emergence of Stensen's duct as a reference landmark. According to our observations, the relationship between the buccal branches and Stensen's duct was much more complicated than described in previous studies. This was the first study to investigate the complete distribution of buccal branches of the facial nerve emerging from the anterior of the parotid gland, and their relative locations and branching numbers.

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1. Introduction

The buccal branches of the facial nerve innervate facial expression muscles in the midface. Their close proximity to Stensen's duct means that the relationship between the two structures has been much studied over the years (Erbil et al., 2007; Hwang et al., 2005; Lee et al., 2014; Liu et al., 2007; Pogrel et al., 1996; Richards et al., 2004; Saylam et al., 2006). Great variation exists in the number and arrangement of buccal branches, possibly as a result of ethnological differences and the lack of a universally recognized definition.

The buccal branches emerge from the anterior border of the parotid gland, and become more superficial as the nerve progresses anteriorly (Levesque and de la Torre, 2015). The risk of injury to the buccal branches exists for many surgeries, including the management of facial trauma in the cheek, especially the surgical repair of Stensen's duct, for example via ligation (Lazaridou et al., 2012; Lewkowicz et al., 2002; Steinberg and Herrera, 2005), superficial parotidectomy through retrograde dissection using a buccal branch as a guide (Mahmood, 2012; Sharma et al., 2011), mid-face rhytidectomy (Levesque and de la Torre, 2015; Cotofana et al., 2015; Mendelson et al., 2008; Nagai et al., 2012; Zani et al., 2003), and wide excision of accessory parotid gland tumor (De Riu et al., 2011; Choi et al., 2012; Newberry et al., 2014). Iatrogenic injury can limit upward movement of the upper lip and oral commissure (Byun et al., 2011), and can lead to loss of the nasolabial fold (Zhai et al., 2015) and asymmetry (Prabhu et al., 2012). Nowadays, nerve detection plays an important role in parotid surgery, although when this is not the case it vital to understand the basic anatomy.

The intertragic notch, lateral canthus (Erbil et al., 2007), tragon, and zygion (Lee et al., 2014) have all been used as anatomical landmarks to identify the buccal branches. Variation, both in the facial skeleton and soft tissue, can significantly influence location. For this study, the relatively constant position of the emergence point of Stensen's duct at the anterior border of the parotid gland was chosen as a reference landmark from which to identify the distribution of buccal branches.

The aim of this study was to identify the distribution of buccal branches, as well as their position relative to Stensen's duct in Taiwanese adult cadavers.

2. Materials and methods

This research was approved by the Institutional Review Board of Kaohsiung Medical University Hospital (IRB Number: KMUB-E(I)-20150146).

2.1. Samples

Twenty-three adult cadavers (18 males, five females; mean age 62.87 ± 14.63 years) were dissected in the laboratory of the Department of Anatomy, Kaohsiung Medical University, during the period 2014–2015.

2.1.1. Exclusion criteria

11 of the 46 hemifaces were excluded as a result of severe destruction caused by head and neck cancer, or accidental damage during dissection. Thus, 35 hemifaces were included in this study.

2.2. Dissection procedure

A preauricular incision was extended superiorly to the temporal region, connected inferiorly with a retromandibular incision, and extended anteriorly. This was then connected with a submandibular incision parallel to the inferior border of the mandible and as far as the midline.

A proposed imaginary line was described from the midpoint of the upper lip to the tragus of the ear, to delineate and predict the approximate trajectory of the parotid duct in the buccal region (Gardetto et al., 2002; Mendelson et al., 2008). In accordance with this imaginary line, dissection of the SMAS (superficial musculo-aponeurotic system) was initiated in the area of the assumed position of Stensen's duct, near the anterior border of the parotid gland. Once Stensen's duct had been identified, the buccal branches of the facial nerve could be easily found superior and/or inferior to the duct (Fig. 1).

2.3. Defining the buccal branches of the facial nerve

The facial nerve branches were dissected from their emergence point at the anterior edge of the parotid gland to their point of insertion in or beneath the facial expression muscles. In accordance with *Gray's Anatomy* (40th edition), the buccal branches of the facial nerve were identified using innervated facial expression muscle. Superficial branches run beneath subcutaneous fat and

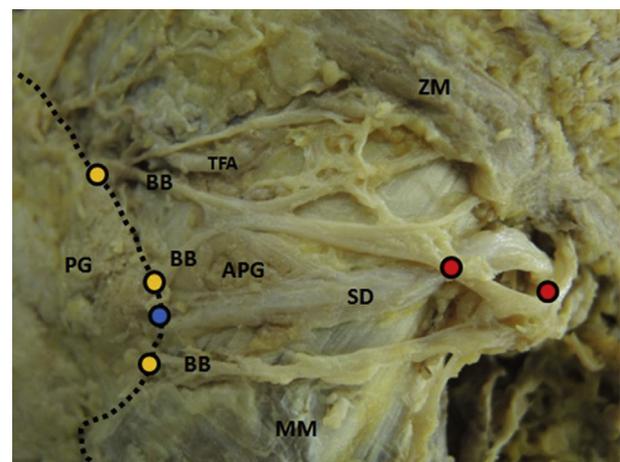


Fig. 1. Buccal region following dissection of SMAS. PG, parotid gland; APG, accessory parotid gland; BB, buccal branch; SD, Stensen's duct; ZM, zygomaticus major; TFA, transverse facial artery; MM, masseter muscle; blue point, emergence of Stensen's duct; yellow point, emergence of buccal branch; red point, intersection of buccal branch (facial nerve) and Stensen's duct; dotted line, anterior border of parotid gland.

superficial musculo-aponeurotic system (SMAS). Some branches pass deeper to the procerus and join the infratrochlear and external nasal nerves. Upper deep branches supply the zygomaticus major and levator labii superioris, and form an infraorbital plexus with the superior labial branch of the infraorbital nerve. They also supply the levator anguli oris, zygomaticus minor, levator labii superioris alaeque nasi, and the small nasal muscle; these branches are sometimes described as lower zygomatic branches. Lower deep branches supply the buccinator and orbicularis oris, and communicate with filaments of the buccal branch of the mandibular nerve.

2.4. Measurement

The distance between the emergence of Stensen's duct and the intersection point of each buccal branch and Stensen's duct was measured (labeled as S in Fig. 2). D in Fig. 2 represents the distance between the emergence point of Stensen's duct and the superiorly located buccal branch (relative to Stensen's duct). Distance d was measured from the emergence point of Stensen's duct and the emergence point of the inferiorly located buccal branch (relative to Stensen's duct). All the above data were measured at least three times using a digital caliper (Mitutoyo®, Kawasaki, Japan). Intra- and inter-observational errors were all found to be negligible ($p > 0.05$).

2.5. Statistical analysis

Statistical analysis was performed using SPSS 14.0 software. A *t*-test was used to compare the distances (D, d) from the emergence of Stensen's duct to the first buccal branch (superiorly and inferiorly) among the different patterns of buccal branch distribution. Values were considered significantly different when the *p* value was less than 0.05.

3. Results

3.1. Intersection of buccal branches and Stensen's duct

In the 35 hemifaces, the number of intersections of buccal branches and Stensen's duct ranged from one to five (average 2.49 ± 1.15). Those with two intersection points (Fig. 3) accounted

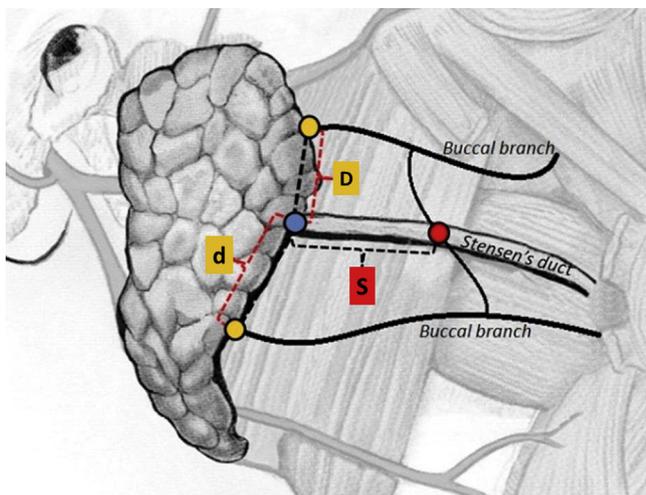


Fig. 2. Measurement of distances. S, distance between emergence of Stensen's duct and intersections; D, distance between emergence of Stensen's duct and superiorly located buccal branches; d, distance between emergence of Stensen's duct and emergence of inferiorly located buccal branches.

for 37% of the sample (13 hemifaces), forming the largest group. Three intersection points made up the second-largest group, at 23% (eight hemifaces). One intersection point was found in seven hemifaces (20% of the sample). Four intersection points occurred in five hemifaces (14%). Finally, five intersection points were found in only two hemifaces (6%).

3.2. The distance from the emergence of Stensen's duct to the intersection point

The mean distance between the emergence of Stensen's duct and the intersection points holds important surgical significance in terms of the number of intersections (Fig. 4). The distance ranged from 2.56 mm to 58.95 mm. The two intersection point group (the largest) had a mean distance 23.31 ± 8.78 mm from the emergence point of Stensen's duct to the first intersection point, and a mean distance of 37.84 ± 5.25 mm from the emergence point of Stensen's duct to the second intersection point. The mean distance from the emergence to the intersection point in the one intersection point group was 26.03 ± 10.21 mm. The three intersection point group was found to have a mean distance of 14.70 ± 9.40 mm from the emergence to the first intersection point, with values for the second and third intersections being 27.37 ± 10.59 mm and 36.67 ± 7.95 mm respectively. The mean distances from the emergence to the first intersection point for the four intersection point group was 12.63 ± 9.52 mm, while that for the five intersection point group was 7.85 ± 7.84 mm.

3.3. The relationship between the emergence of buccal branches and Stensen's duct

3.3.1. The classification and distribution of the buccal branches of the facial nerve, relative to Stensen's duct

Our samples were classified into four types (Table 1 and Fig. 5) according to the distribution of the buccal branches of the facial nerve, and by using Stensen's duct as the reference landmark. Type I (Fig. 5(a)) comprised those with two buccal branches, accounting for 37.15% of the sample (13/35). Type I-a was made up of those with one superior buccal branch and one inferior buccal branch, accounting for 22.86% of our sample. Type I-b (5/35; 14.29%) comprised those with two superiorly located buccal branches, with no inferior buccal branch.

Type 2 (Fig. 5(b)) had three buccal branches, and accounted for 48.59% (17/35) of our sample, forming the biggest group. Type 2-a was the most frequent pattern among our samples, with two superior buccal branches and one inferior buccal branch, accounting for 34.31% of our sample. Type 2-b had one superior buccal branch and two inferior buccal branches, accounting for only 8.57%. There was only one hemiface (1/35; 2.85%) with three superior buccal branches (Type 2-c). Type 2-d, with one superior buccal branch, one inferior buccal branch, and, interestingly, one branch emerging from the same level as Stensen's duct, was only found in one hemiface (1/35, 2.85%).

Type 3 was defined as having four buccal branches, accounting for only 5.7% of the sample. Type 3-a, with three superior buccal branches and one inferior buccal branch was found in only one hemiface (1/35, 2.85%). Type 3-b, with two superior buccal branches and two inferior buccal branches, was also found in only one hemiface (1/35; 2.85%).

It is worth mentioning that there were three cases of double Stensen's duct in this study, which we classified as Type 4. According to Astik, this a very rare anatomical variation.

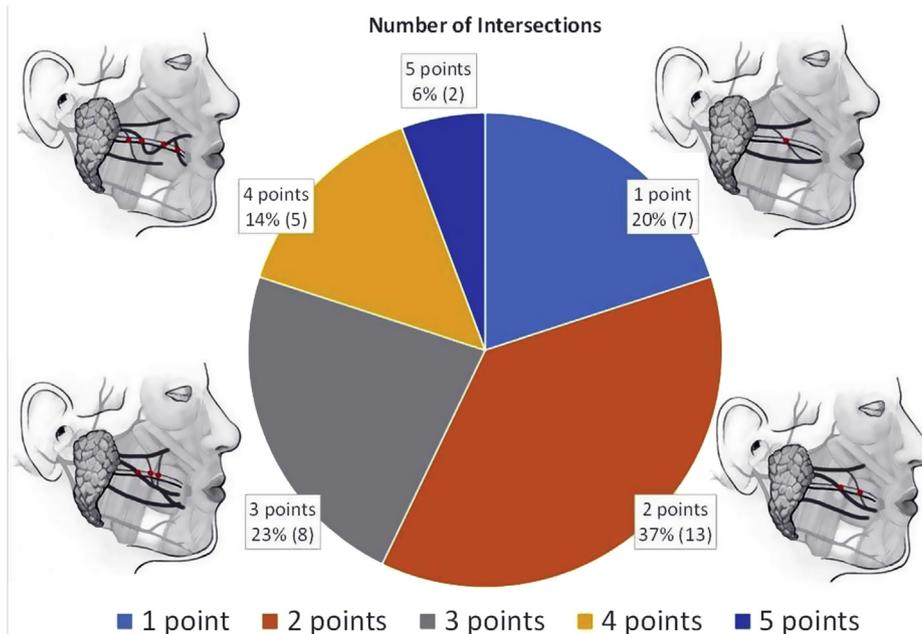


Fig. 3. Number of intersections between buccal branches and Stensen's duct.

3.3.2. Distances between the buccal branch emergence points and Stensen's duct, along the anterior border of the parotid gland

Table 1 shows the distances between the buccal branches emergence points and Stensen's duct. For Type 2a (Fig. 6), the most frequent pattern among our specimens, the distance from Stensen's duct to the emergence point of the first superior buccal branch along the anterior border of the parotid gland (D1) was 9.58 ± 5.68 mm. The distance from the Stensen's duct to the emergence of the second superior buccal branch along the anterior border of the parotid gland (D2) was 18.34 ± 8.34 mm. The distance from Stensen's duct to the emergence of the inferior buccal branch along the anterior border of the parotid gland was 11.03 ± 5.38 mm.

Type 1a is also of great clinical significance (Table 1). The distance (D1) from Stensen's duct to the emergence point of the superior buccal branch of the facial nerve was 14.75 ± 6.11 mm. The distance (d1) from emergence point of Stensen's duct to the emergence point of inferior buccal branch of facial nerve is 10.37 ± 4.63 mm.

The distance (D1) from Stensen's duct to the emergence of the first superiorly located buccal branch of the group Type 2-a was statistically different from the distance (D1) of the other groups ($p = 0.02$). The distance (d1) from Stensen's duct to the emergence of the first inferiorly located buccal branch of the group Type 2-a was not statistically different from that (d1) of the other groups ($p = 0.262$).

3.3.3. Anastomoses between superior and inferior buccal branches

No direct anastomoses or communicating fibers between upper and lower buccal branches were noted in 11 hemifaces (31%).

4. Discussion

For this study the emergence point of Stensen's duct from the anterior border of the parotid gland was used as a reference landmark to depict the distribution of the buccal branches of the facial nerve of the mid-face, including the emergence of the buccal branches from the parotid gland, and the intersection between buccal branches and Stensen's duct.

Reviewing the literature (Erbil et al., 2007; Pogrel et al., 1996; Richards et al., 2004; Saylam et al., 2006), some studies describe the intersections formed by the looping of buccal branches over Stensen's duct (Erbil et al., 2007; Richards et al., 2004), or the course of the main trunk of the buccal branch and its division crossing over Stensen's duct (Pogrel et al., 1996; Saylam et al., 2006). Our study also showed the crossing of buccal branches over Stensen's duct, but with more intersections than described in past studies. We found great variation in both numbers and courses of the buccal branches. Instead of the simple loops described in past studies, multiple communicating fibers connecting buccal branches were noted in our Taiwanese cadaver samples. Sometimes the main trunk of the buccal nerve followed a curved course, crossing over Stensen's duct, and then a less curved course before going beneath the facial expression muscle. Uniquely, our study observed a high frequency of multiple intersections formed between the buccal branches and Stensen's duct (Fig. 3). The mean distances from the emergence of Stensen's duct to each intersection point were shown in this study. These data are of clinical significance in avoiding facial nerve injury when performing ligation of Stensen's duct or retrograde dissection.

Table 2 shows data on the average number of buccal branches of the facial nerve. The average number of buccal branches in our study was 2.69 ± 0.58 , with at least two buccal branches in each cadaver, in contrast to a wide distribution of single branches in one study from the US (Pogrel et al., 1996), and two studies from Turkey (Erbil et al., 2007; Saylam et al., 2006). Ethnological differences might therefore exist regarding the number of buccal branches of the facial nerve. Previous studies suggest that branching of the buccal nerve of the facial nerve might be more of a feature among the Mongoloid races, compared with the Caucasoids. The Taiwanese population comprises a wide variety of ethnic groups, including Min, Hakka, Mandarin, and Austronesian aborigines. Therefore, wide variation was noted within our sample.

Only a few studies have clearly defined the buccal branches in the literature. This might influenced their results.

Pogrel et al. (1996) emphasized that 'once the parotid duct has been identified, the buccal branch is most likely found inferiorly

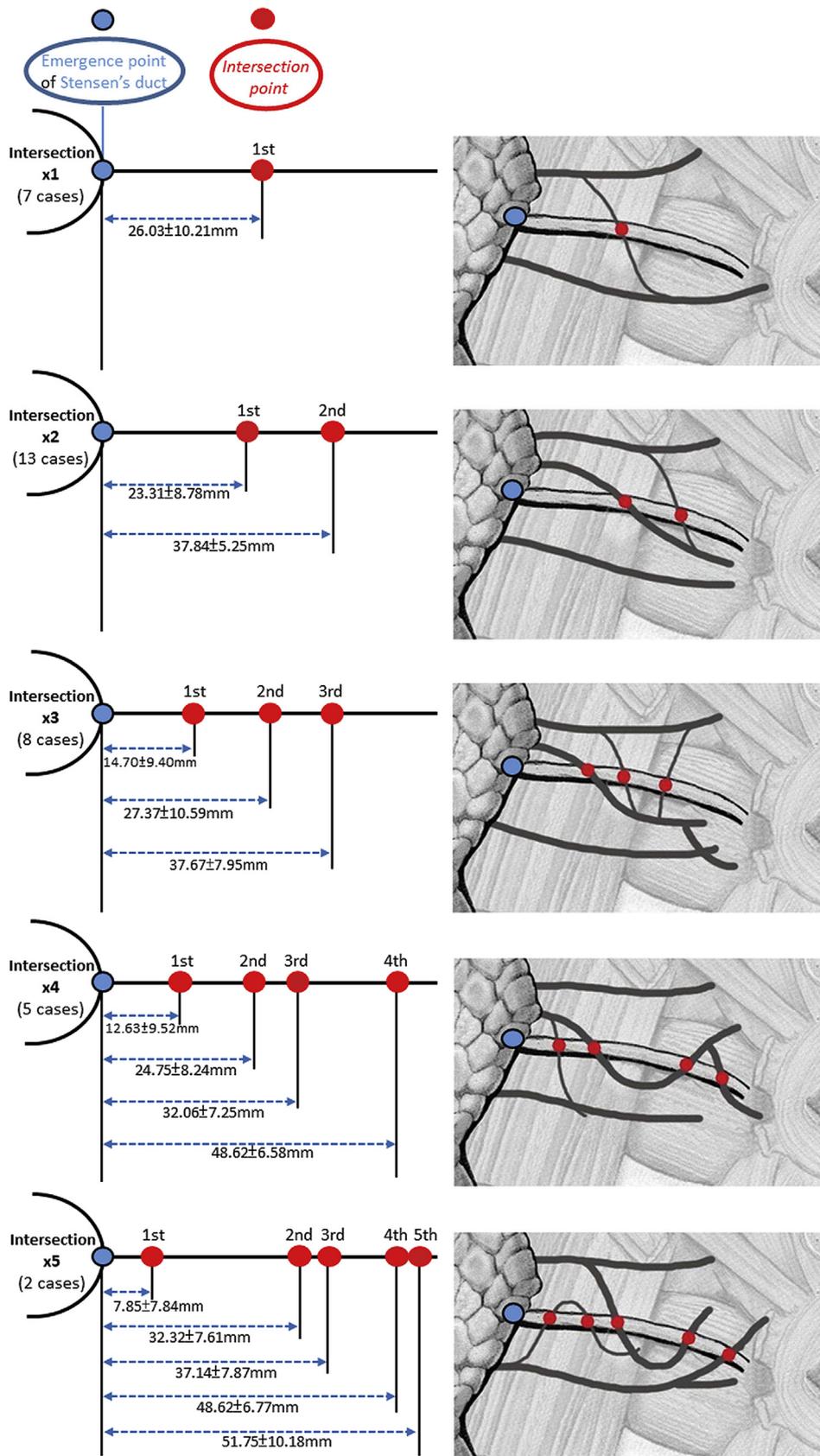
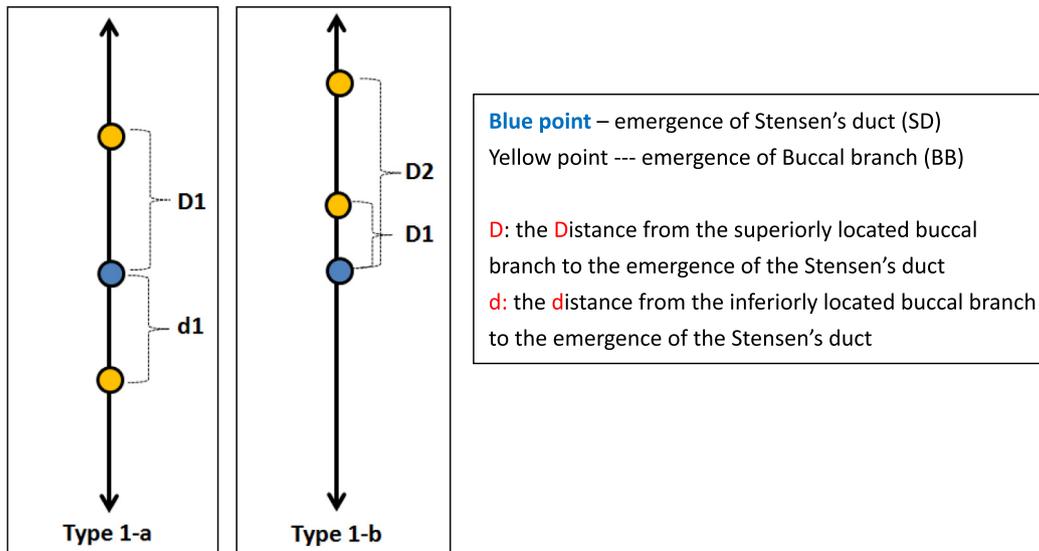


Fig. 4. Mean distance between emergence of Stensen's duct and intersections.

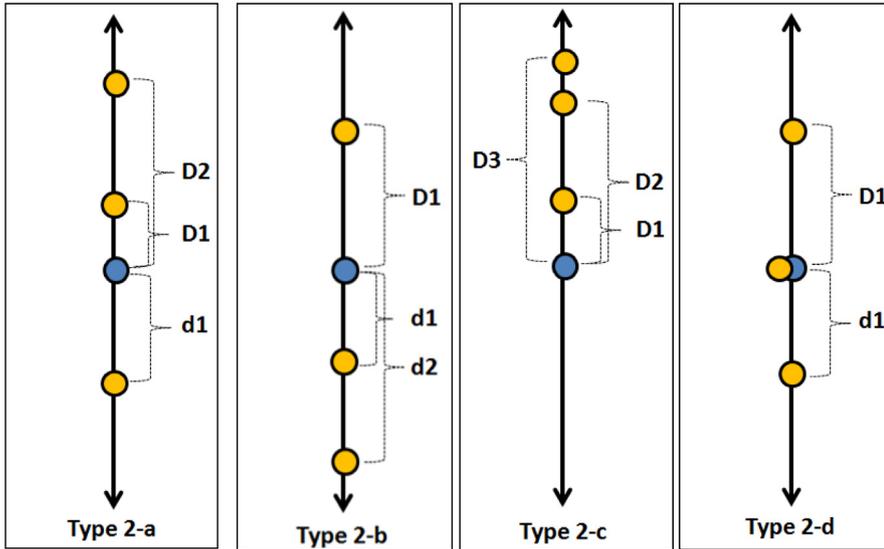
Table 1
Distances between the respective emergence point of buccal branch and Stensen’s duct, along the anterior border of parotid gland.

Type 1: Two buccal branches: 13/35 (37.15%)						
Type 1-a (1 BB sup./1 BB inf.) : 8/35 (22.86%)						
	D3	D2	D1	Stensen’s Duct	d1	d2
Mean			14.75±6.11 mm		10.37±4.63 mm	
Type 1-b (2 BB sup./No BB inf.) : 5/35 (14.29%)						
	D3	D2	D1	Stensen’s Duct	d1	d2
Mean		18.12±8.67mm	6.59±5.99 mm			

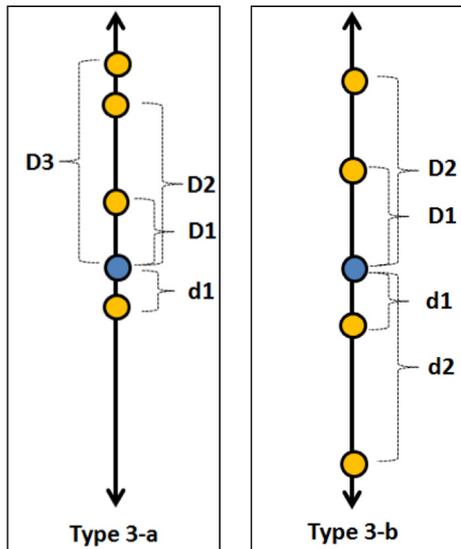


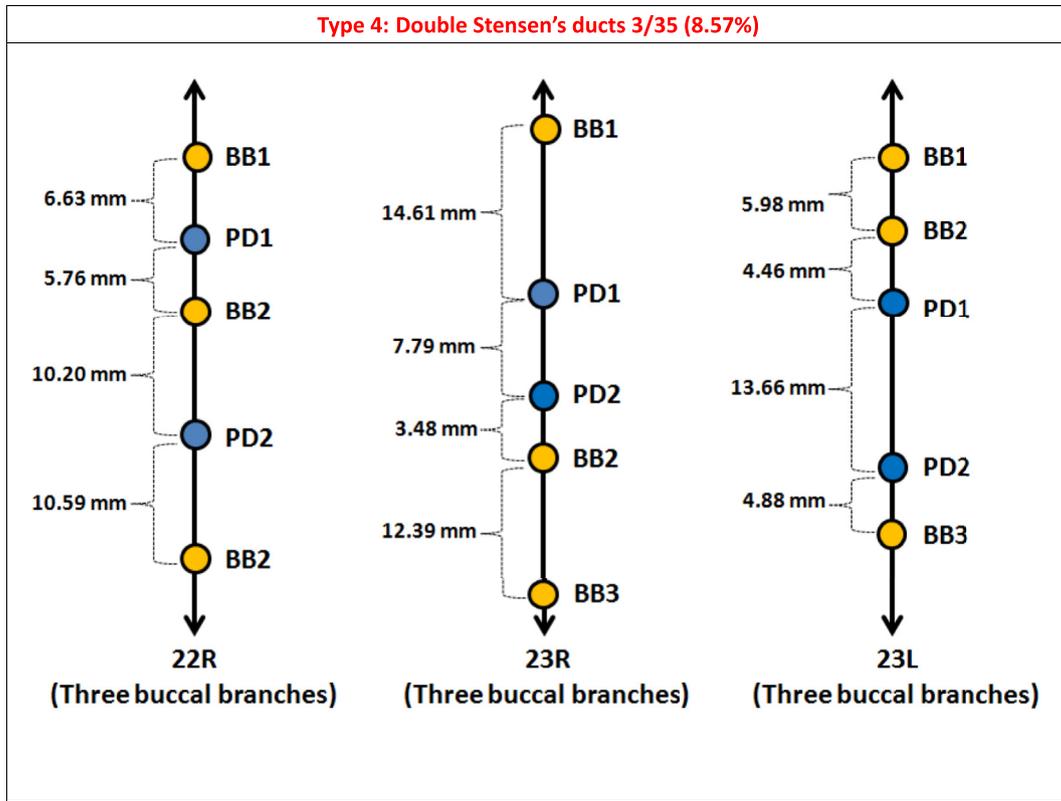
Type 2: Three buccal branches: 17/35 (48.58%)						
Type 2-a (2 BB sup./1 BB inf.) : 12/35 (34.31%)						
	D3	D2	D1	Stensen’s Duct	d1	d2
Mean		18.34±4.98 mm	9.58±5.68 mm		11.03±5.38 mm	
Type 2-b (1 BB sup./2 BB inf.) : 3/35 (8.57%)						
	D3	D2	D1	Stensen’s Duct	d1	d2
Mean			16.42±3.37mm		7.84±2.87 mm	20.81±5.19 mm
Type 2-c (3 BB sup./No BB inf.) : 1/35 (2.85%)						
	D3	D2	D1	Stensen’s Duct	d1	d2
Mean	22.17mm	19.22mm	7.12mm			
Type 2-d (1 BB sup./1BB inf./1 BB at the same emergence of Stensen’s duct) : 1/35 (2.85%)						
	D3	D2	D1	Stensen’s Duct	d1	d2
Mean			14.89mm		6.64mm	

Type 2-d: There are three buccal branches, one superiorly located, one inferiorly located and one emerging from the exact emergent point of Stensen’s duct



Type 3: Four buccal branches: 2/35 (5.70%)						
Type 3-a (3 BB sup./1 BB inf.) : 1/35 (2.85%)						
	D3	D2	D1	Stensen’s Duct	d1	d2
Mean	9.39mm	6.42mm	1.58mm		1.58mm	nil
Type 3-b (2 BB sup./2 BB inf.) : 1/35 (2.85%)						
	D3	D2	D1	Stensen’s Duct	d1	d2
Mean	nil	15.38mm	9.96mm		5.86mm	27.40mm

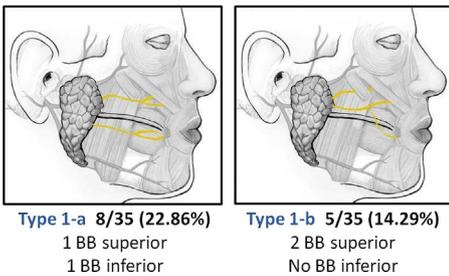




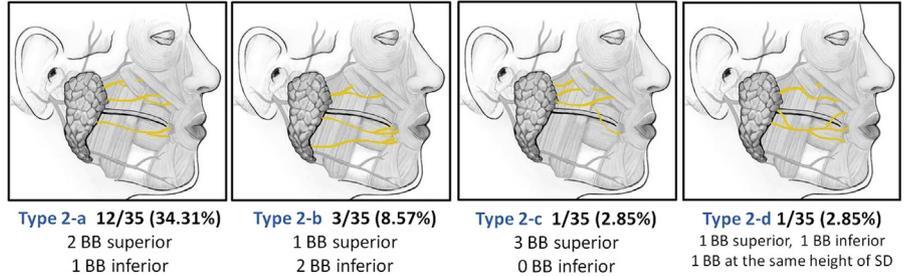
and within 1 cm'. This is in agreement with our results, in which the mean distance was 10.35 ± 5.47 mm in cases with one buccal branch inferior to the emergence of Stensen's duct, i.e. the d1

distance for Type 1-a (1 BB sup./1 BB inf.); Type 2-a (2 BB sup./1 BB inf.); Type 2-d; Type 3-a (3 BB sup./1 BB inf.). However, only Liu's (Liu et al., 2007) study mentioned the location of the buccal branch

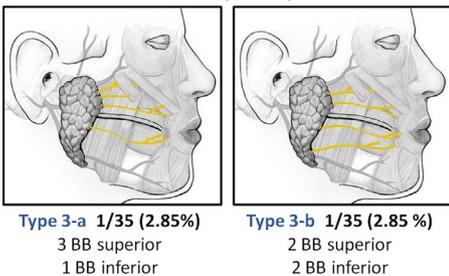
a Type 1: Two Buccal Branches
13/35(37.15%)



b Type 2: Three Buccal Branches
17/35(48.58%)



c Type 3: Four Buccal Branches
2/35(5.7%)



d Type 4 : Double Stensen's duct
3/35(8.57%)

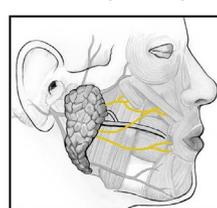


Fig. 5. Distribution of buccal branches of facial nerves, relative to Stensen's duct. (a) Type I — two buccal branches; (b) Type II — three buccal branches; (c) Type III — four buccal branches; (d) Type IV — double Stensen's duct; (e) example of double Stensen's duct.

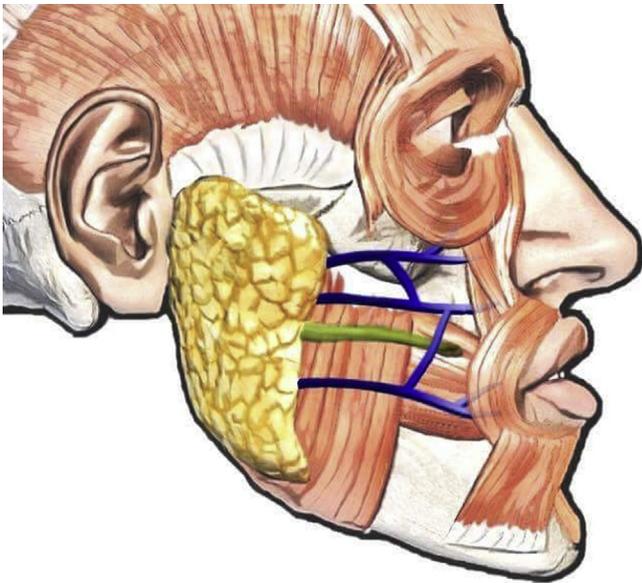


Fig. 6. Type IIa was the most frequent pattern of buccal branching of the facial nerve among our samples.

as being 10.7 mm superior to the emergence of Stensen's duct. In our study, 40% of our samples showed one superior buccal branch — Type 1-a (1 BB sup./1 BB inf.), Type 2-b (1 BB sup./2 BB inf.), and Type 2-d — with the point of emergence of this superior buccal branch being 14.80 ± 4.70 mm above the emergence of Stensen's duct.

This is the first study to investigate the complete distribution of buccal branches of the facial nerve emerging from at the anterior edge of the parotid gland, along with their relative locations and branching numbers. The results could offer a useful reference for superficial parotidectomy with a retrograde approach. Mahmood et al. advised that this dissection should be based on buccal branches because of their constant relation with Stensen's duct. Improved identification of the buccal branches should result in a low incidence of nerve damage and temporary facial nerve weakness (Mahmood, 2012). Currently, nerve detection plays an important role in parotid surgery, though it is important to have an understanding of the basic anatomy and anatomical variation for when nerve detection is not used.

Masses arising in the accessory parotid tissue usually occur around the central third of a line drawn from the tragus to the bottom of the ala of the nose, parallel to the main parotid duct, and also along the course of the buccal branch of the facial nerve (Polayes and Rankow, 1979). Standard parotidectomy incision is the most recommended approach for tumor excision because of maximal tumor exposure and clear visualization of the distal branch of the facial nerve. The tumor–nerve relationship can involve the facial nerve lying over or wrapping around the tumor (De Riu et al., 2011). Therefore, Choi et al. (2012) and Newberry et al. (2014) both emphasized identification of buccal branches at the anterior border of the parotid gland and tracing along the nerves to the mass as an important procedure before tumor excision, in order to preserve the facial nerve in surgery. Information on the distribution of facial nerve branches (buccal branches) superior to the emergence of Stensen's duct was lacking in the literature, hence the focus of our study. In our study, accessory parotid gland was evident in three of the 35 specimens (8.57%), and in all cases the first buccal branch superior to the emergence of Stensen's duct went along the superior border of the accessory parotid gland, and then crossed Stensen's duct (Fig. 1).

In their study, Saylam et al. found no regular pattern of arborization of the buccal branches, so it was truly difficult to make a classification of the relationship between the buccal branches and Stensen's duct. Our study made a simple division into two groups: anastomosis between the upper and lower deep buccal branches, or no anastomosis. Of our specimens, 69% showed anastomoses, with none evident in the other 31%. Zhai et al. designated the upper buccal branch as an unimportant branch of the facial nerve, because trauma to this branch causes relatively minor facial complications. They proposed that it was acceptable to sacrifice the upper buccal branch in order to reconstruct the defect associated with the zygomatic branch. They claimed that dysfunction of the nasolabial fold, caused by harvesting of the upper buccal branch during the operation, would be recovered quickly thanks to abundant communications between upper and lower buccal branches (Zhai et al., 2015). However, in our observations, anastomosis was not found in 31% of the cases, so we speculate that long-term dysfunction of the facial expression muscle could still be possible.

Although we offer precise information on the distribution of buccal branches in our study, the high variability suggests that they could appear anywhere along the anterior border of the parotid gland or along Stensen's duct. Therefore, we would always recommend a cautious approach, in order to avoid damage to buccal branches during surgery.

Table 2
Study on number of buccal branches of facial nerve and distribution.

Year	Authors	Average No.	Country	n=1	n=2	n=3	n=4	plexus
1996	Pogrel	1.15	US	85%	15%			
2002	Gardetto	2.14	Austria	5%	80%	10%	5%	
2005	Hwang	3.6 ± 0.6	Korea	Ranging from 2 - 3				
2006	Saylam	Not mentioned	Turkey	60%	13%			26.7%
2007	Eribil	1.6	Turkey	40%	60%			
2007	Liu	Not mentioned	China	Ranging from 3 - 5				
2011	Kirici	1.84	Turkey	16%	84%			
2013	Lee	2.16	Korea	12.7%	58.2%	29.1%		
2015	Karey	2.0	India		100%			
2017	Ko et al.	2.69 ± 0.58	Taiwan		37.1%	57.2%		5.1%

5. Conclusion

Surgeons should be advised to take the utmost caution when dissecting either the buccal branches or Stensen's duct, because of wide variability in the population. We depicted the distribution of buccal branches using the emergence of Stensen's duct as a reference landmark. In our observations, the relationship between the buccal branches and Stensen's duct was much more complicated than described in previous studies. This result might also reflect the great diversity of ethnic origins among the Taiwanese population, and the limited number of previous studies on this issue.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jcms.2018.12.018>.

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