Extracranial course of the facial nerve revisited

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ABSTRACT

Introduction: The extrapetrous course of the facial nerve has been a matter of study and debate since XIX century. Two different classifications have been classically proposed and widely accepted by most of the authors. Nevertheless, there are reported cases which do not fit in any of those. The aim of this study is to propose a new and useful classification.

Material and methods: We have used 23 embalmed Caucasian adult cadavers (11male and 12 female) belonging to the Bodies Donation and Dissecting Rooms Centre of the University Complutense of Madrid. The extra-petrous facial nerve was dissected in the possible specimens resulting in 38 facial nerves. The studied parameters were length, diameter of divisions, terminal branches and nerve connections.

Results: In every specimen two main divisions were found, temporofacial and cervicofacial. They divided into five terminal branches from cranial to caudal: temporal, zygomatic, buccal, marginal or mandibular and cervical. Based on the comparison with previous proposed classifications, we have unified the patterns in 12 types being the most frequent types the type 3 (8 cases, 21.05%), with connections between temporal, zygomatic and buccal branches and the type 8 (8 cases, 21.05%), a complex network between temporal, zygomatic, buccal and mandibular branches.The number of terminal branches was so variable.

Conclusion: We propose a new twelve-patterned classification which summarises the previous ones. However, we consider that a good study of the number of terminal branches, connections between branches or with other cranial nerves are more useful for surgeons to avoid injuries to the facial nerve during surgery than complex classifications.

INTRODUCTION

Facial palsy is still an important consequence from a parotid surgery (Bittar et al., 2016). The facial nerve gives, in its extracranial course, two main divisions in the parotid area, the temporofacial and the cervicofacial branches, which finally give off five terminal branches (Shoja and Tubbs, 2016). These branches give the motor supply to the facial or mimetic muscles. Injury to any of those branches may result in a facial palsy. Since the end of the nineteenth century the extrapetrous course of the facial nerve has been object of many studies (Luschka, 1862; Cruveilhier, 1867; Davis et al., 1956; Katz and Catalano, 1987; Yang et al., 2013).

It is well-known that the facial nerve is distributed in a plexiform arrangement with several ramifications of the terminal branches named, by the classical authors, like the innervated muscular area (Cruveilhier, 1867; Hovelacque, 1927). This structure with multiple connected branches in many cases, has been called "subparotid plexus" and connects branches in the upper division of the nerve (Sappey, 1879; Hovelacque, 1927) with the "buccal component" (McCormack et al., 1945) or "parastenon plexus" (Pons - Tortella, 1947). This complex distribution could be a problem during the parotid gland surgery, not only hindering a lesion removal, but also causing an injury to the nerve (Kidd, 1950).

Some anatomists have tried to look for a classification which unifies, in a simple and useful way, different nerve patterns observed during dissection (McCormack et al., 1945; Dargent and Duroux, 1946; Pons-Tortella, 1947). A different number of types for the facial nerve were proposed, from five (Dargent and Duroux, 1946) to eight (McCormack et al., 1945; Pons-Tortella, 1947). In 1956, Davis et al., studied a sample of 350 facial nerves and proposed six different patterns. This classification was based on the presence of connections between the terminal branches. Posterior studies about the facial nerve types presented their results according

to Davis classification (Bernstein and Nelson, 1984; Myint et al., 1992). However, in 1987 Katz and Catalano described a 5-typed-classification, which did not fit with Davis' classification. They took into consideration two new criteria, the origin and the number of the buccal branch of the facial nerve trunks (Table 1). After that, two main "popular" classifications were published based in types of double trunks (Kopuz et al., 1994) or according to the origin of the buccal branch (Kwak et al., 2004).

Moreover, variability in the facial nerve anatomy, may increase the probability of a facial palsy after surgery if the surgeon is not aware of the different anatomical variations (Lee 2016). Therefore, we have undertaken this study reviewing previous literature and comparing with our own sample, with the aim of proposing a simple and unified classification of facial nerve types and also studying the number of terminal branches with a clinical purpose.

MATERIAL AND METHODS

Thirty-eight facial nerves belonging to the Center of Donation and Dissecting Rooms of the University Complutense of Madrid were studied. All of them were Caucasian adult embalmed cadavers, 11 male and 12 female. In 15 corpses, both sides were dissected and in 8 cases just one side could be studied. Out of 38 specimens, 17 were right (8 from males, 9 from females) and 21 were left sided (9 from males, 12 from females).

The dissection was planned to show the facial nerve patterns in its extra-petrous division inside the parotid gland. First of all, a fascio-cutaneous flap was medially reflected in the parotid area. Afterwards, the dissection was carried out from the posterior portion of the gland to identify the nerve trunk. Next step was opening up the layer where the nerve branches are

between the two gland lobes. The branches were dissected in an anterograde direction until the superficial lobe was removed.

The parameters studied were length, diameter of divisions, number and course of terminal branches and the connections between them. Significant differences between gender and side in the incidence of the variations of the facial nerve were analyzed by means of the Chi-squared and Fisher homogeneity tests with a significance level $\alpha = 0.05$.

RESULTS

The results will be exposed in four sections according to the extra-petrous course of the facial nerve: facial nerve trunk, terminal branches, patterns and connections.

1. The facial nerve trunk and divisions.

We located the exit of the facial nerve from the skull through the stylomastoid foramen in the 38 specimens without mastoidectomy. The mean distance between the emerging point of the facial nerve trunk from the stylomastoid foramen and its bifurcation point was 14.38+-3.04 mm (range 7.8– 18.47). No significant differences were found by sex (p-value 0.27) or side (p-value 0.73). The mean diameter of the nerve trunk was 2.16+-0.49 mm (range 0.76 – 2.87).

The nerve, after emerging through the stylomastoid foramen, curves downward and ventrolateral and enters the retromandibular fossa lateral to the external carotid artery and the retromandibular vein. In three cases an accessory trunk was observed (3/38, 7.89%) just after entering into the parotid gland (Fig. 3B). Inside the parotid gland, the nerve runs between the deep and superficial lobe until it emerges beyond the anterior border of the gland to continue until the facial muscles (Figs. 1-3).

In every specimen, we found two main divisions after bifurcation, the temporofacial and the cervicofacial branches that finally divided into five terminal branches: temporal, zygomatic, buccal, marginal or mandibular, cervical (Figs. 1-3).

The temporal and zygomatic branches were originated always from the temporofacial division, however, the mandibular and cervical always arose from the cervicofacial division (Figs. 1-3). The buccal branch is the only with one variable origin (Figs. 1-3).

2. Terminal Branches

We describe the terminal branches from superior to inferior in a clockwise way.

2.1 Temporal branch

The temporal branch emerged from the superior limit of the parotid gland and crossed upwards the zygomatic arch giving between one to five distal branches (Table 2). These branches supply, the frontalis, orbicularis oculi and corrugator muscles. The point where the temporal branch leaves the gland is inferior to the point of bifurcation of the superficial temporal artery (Figs. 1-3). The average length for the temporal branch was 30.10mm with a standard deviation of 6.89mm (Table 3). The average diameter for the temporal branch was 0.93mm with a standard deviation of 0.32mm (Table 3).

2.2. Zygomatic branch

The zygomatic branch supplied the orbicularis oculi and zygomatic muscles, it usually has a number of twigs ranged from one to three (Table 2). It runs always below and nearly parallel to the zygomatic arch to reach the lower part of the orbicularis oculi muscle (Figs. 1- 3). The average length for the zygomatic branch was 38.02mm with a standard deviation of 6.64mm

(Table 3). The average diameter for the zygomatic branch was 1.00mm with a standard deviation of 0.45mm (Table 3).

2.3. Buccal branch

The buccal branch presented the most variable origin. It run with the parotid duct over the masseterus and buccinator muscles (Figs. 1-3). It usually gave one to three branches (Table 2). It supplied the zygomatic muscles, orbicularis oris and levator labii superioris. In 18 cases (47.37%) it arose from the temporofacial division, in 16 cases (42.11%) from the cervicofacial division and in 4 cases (10.52%), it had a double origin, one twig originated from the temporofacial division and the other from the cervicofacial division (Fig. 1C). The average length for the buccal branch was 37.87mm with a standard deviation of 7.33mm (Table 3). The average diameter for the buccal branch was 0.99mm with a standard deviation of 0.39mm (Table 3).

2.4. Mandibular branch

The mandibular branch run over the facial artery as it crossed the lower limit of the mandible (Figs. 1-3). It innervated the depressor labii inferioris. In 32 of the 38 nerves (84.2%) showed only a single branch, however, in 6 cases (15.8%) it had two branches (Fig. 2A, Table 2). The average length for the mandibular branch was 33.13mm with a standard deviation of 8.98mm (Table 3). The average diameter for the mandibular branch was 0.9mm with a standard deviation of 0.34mm (Table 3). The average diameter for the mandibular branch was significant smaller (p-value 0.057) when a unique branch was presented (average 0.75, standard deviation 0.30) compared to the case in which two branches were presented (average 1.06, standard deviation 0.44).

2.5. Cervical branch

The cervical branch, which innervates the platysma muscle, gave one to three distal twigs as it went downward to the neck (Table 2). The average length for the cervical branch was 40.55mm with a standard deviation of 12.78mm (Table 3). The average diameter for the cervical branch was 0.82mm with a standard deviation of 0.15mm (Table 3).

No significant correlations between the lengths and diameters of the facial nerve trunk and the terminal branches were found. However, a positive and statistically significant correlation between the length of the temporal and cervical branches (correlation = 0.532), buccal and mandibular branches lengths (correlation = 0.486), mandibular and cervical branches lengths (correlation = 0.402) and the zygomatic and buccal branches diameters (0.309) were found.

3. Patterns

Unifying previously proposed classifications and considering the early mentioned three criteria: connections, buccal branch origin and facial nerve number of trunks, we have classified our findings into 12 different types (Fig. 4, Table 4).

Type 1, without connections between terminal branches and the buccal branch arose from either temporofacial or cervicofacial division (Fig. 1A and Table 5).

Type 2, Without connections between terminal branches, double mandibular branch and the buccal branch originated from the cervicofacial division (Table 5).

Type 3, With connections between temporal, zygomatic and buccal branches, the buccal branch arose from either temporofacial or cervicofacial division (Figs. 2B, 3C and table 5).

Type 4, With a temporofacial-cervicofacial connection. The buccal branch arose from the cervicofacial division (Fig. 2A, 2C and Table 5).

Type 5, With a buccal-mandibular connection. The buccal branch arose from the temporofacial division (Table 5).

Type 6, With connections between temporofacial branches and the temporofacial and cervicofacial divisions. The buccal branch originated from the cervicofacial (Table 5)

Type 7, With connections between temporofacial and cervicofacial connections. The buccal branch originated from the cervicofacial division (Table 5)

Type 8, With a complex network of connections between temporal, zygomatic, buccal and mandibular. The buccal branch could arise from either temporofacial or cervicofacial division (Figs. 1B, 3A and Table 5)

Type 9, it is similar to type 8 but the buccal branch originates from two roots: temporofacial and cervicofacial divisions (Fig. 1C and Table 5).

Types 10, Characterized for having a double facial trunk, the accesory trunk is connected with the temporofacial division (Table 5).

Type 11, a double facial nerve, from the main trunk arose the temporofacial division and from the accesory trunk arose the cervicofacial one (Fig. 3B and Table 5).

Type 12, a double facial nerve, the accesory trunk connected with the cervicofacial division (Table 5).

No statistically significant differences by sex (p-value 0.583) or side (p-value 0.379) were found (Table 5).

4. Connections between branches

According to the connections between branches. We have observed the following connections:

- Temporal-Zygomatic: 11 cases (28.95%) where 9 cases (23.68%) presented a unique connection and 2 cases (5.3%) presented two connections (Figs. 1B, 2B, 3C).
- Zygomatic-Zygomatic: 5 cases (13.16%) where 3 cases (7.89%) presented a unique connection, one case (2.63%) presented two connections and one case (2.63%) presented three connections.
- Zygomatic-Buccal: 23 cases (60.53%) where 18 cases (47.36%) showed a unique connection, 4 cases (10.52%) presented two connections, and one case (2.63%) presented three connections (Figs. 1B-C, 2A, 2C, 3A).
- Buccal-Buccal: 7 cases (18.42%) where 4 cases (10.52%) presented a unique connection and 3 cases (7.89%) presented two connections (1C, 2B).
- Buccal-Mandibular: 16 cases (42.11%) where 9 cases (23.68%) presented a unique connection, 6 cases (15.78%) presented two connections, and one case (2.63%) presented three connections (1A, 3A).
- Mandibular-Cervical: 2 cases (5.26%) that presented a unique connection

We also recognized in every specimen connection between the facial and trigeminal nerves: the zygomatic and/or buccal branches with the infraorbitary nerve (Fig. 3C) and the mandibular branch with the mental nerve (Fig. 5).

DISCUSSION

The discussion will be exposed in four sections according to the exposition done in results section.

1. The facial nerve trunk

A single facial nerve trunk going through the stylomastoid foramen, has been often described in the literature (Davis et al., 1956; Gataa and Faris, 2016). However, several authors described two different trunks (Katz and Catalano, 1987; Kopuz et al., 1994; Kwak et al., 2004, Kilic et al., 2010). Our results agree with the last statement. These patterns were classified as types 10 to 12.

2. Terminal Branches

Since the XIX century, the two main divisions of the facial nerve "*temporofaciale et cervicofaciale*" were described inside the parotid gland (Cruveilhier, 1867; Hovelacque, 1927) and the terminal branches were described according to the muscle group they innervated (Cruveilhier, 1867; Hovelacque, 1927). Cruveilhier reported seven branches: "*temporaux, frontaux, orbitaires, nasaux, buccaux, mentonnieres, cervicaux"* (Cruveilhier, 1867) and Hovelacque described eight branches, with different terminology: "*temporaux, frontaux, palpebraux, sous-orbitaires, buccaux supérieurs, buccal inférieur, mentonniers, cervicaux*" (Hovelacque, 1927). Posterior authors focused their attention on the parotid plexus observed in the midface rather than the individual terminal branches (McCormack et al., 1945; Pons-Tortella, 1947), and in 1956, with Davis classification, the classical names for the terminal branches were recovered. The classical terminology was simplified by Davis in five branches: temporal, zygomatic, buccal, mandibular and cervical (Cruveilhier, 1867; Hovelacque, 1927; Davis et al., 1956). However, the classification in six patterns overshadowed the significance of the variability in number and course of the terminal branches. This classification is still used and considered forgetting more classical studies previously published (Cruveilhier 1867; Hovelacque 1927; McCormack et al., 1945; Dargent and Duroux, 1946).

2.1 Temporal branch

The temporal branch can be easily identified as it emerges at the superior border of the parotid gland and crosses over the zygomatic arch to get the fronto-orbital region. It has been described as a single one (Zani et al., 2003; Babakurban et al., 2010), as having three branches (Ammirati et al., 1993), two to four branches (Cruveilhier, 1867; Hovelacque, 1927; Ishikawa, 1990; Gosain et al., 1997; Sabini et al., 2003; De Bonnecaze et al., 2015), or up to six branches (Lineaweaver et al., 1997). We found a variable number of temporal branches, from one to five. This confirms the accepted idea of a multiple temporal branch in the vast majority of cases, sustained even by classical authors (Cruvelhier, 1867; Hovelacque 1927; Pons-Tortella, 1947).

Regarding the relationship of the temporal branches with other important neurovascular structures, the temporal twigs of the facial nerve are located anteroinferiorly to the superficial temporal artery (Gosain et al., 1997; Tayfur et al., 2010). Our results confirm those reports. Therefore, we agree with authors who have described the superficial temporal artery as a safe landmark to preserve the temporal branch while rhytidectomy (Pitanguy and Ramos, 1966; Sabini et al., 2003; Lei et al., 2005).

2.2 Zygomatic branch

The zygomatic branch runs below and parallel to the zygomatic arch to the orbito-nasal area. It has been studied with the aim of searching for a safety zone for dissection (Chatellier et al., 2013). Our results confirm that the zygomatic twig is easy to find in the specimens thanks to the safety zone given by Chatellier et al., (2013), who identified a point between the intertragic notch and the external canthus line, 2.5 cm in front of the intertragic notch.

2.3 The buccal branch

It runs parallel to the parotid duct to get the buccinator muscle. The buccal branch origin has been reported as the most variable of the terminal facial branches, therefore it has been used by some authors to classify the facial nerve in different branching patterns (Katz and Catalano, 1987; Kwak et al., 2004). Other authors have preferred to classify the buccal branch in relation with the parotid duct (Saylam et al., 2006). We have confirmed the variability of origin described in the literature, because in 18 nerves (47.37%), the buccal twig arose from the temporofacial division and in the other 16 nerves (42.11%) from the cervicofacial division. In four cases (10.52%), it originated as a double root from both divisions which join together to form a single branch or a loop.

In the literature, anatomists have talked about a subparotid plexus (Sappey, 1879; Hovelacque, 1927), a buccal component (McCormack et al., 1945), or a parastenon plexus (Pons–Tortella, 1947). We observed, in our results, this plexiform structure of the buccal branch in 12 cases (31.58%), usually surrounding the parotid duct.

2.4. The mandibular branch

The marginal branch showed one to four twigs (Dingman and Graab, 1962; Nelson and Gringrass, 1979; Wang et al., 1991; Batra et al., 2010, Balagopal et al., 2012). We observed a double mandibular branch in six occasions (15.79%). We believe that, even if the mandibular twig can be multiple, it usually has fewer branches than the temporal branch.

It run over the facial vessels in the lower third of the mandible to get the inferior lip. In order to find the mandibular branch, some authors have already looked for the facial vessels as a landmark (Batra et al., 2010).

2.5 The cervical branch

It run downward to get the platysma muscle. It was described as a single branch (15%), a double branch (55%) or having three branches (30%) (Salinas et al., 2009). We just found one case of a double branch (2.6%) and another one with three branches (2.6%).

3. Patterns

After several attempts of classifications (McCormack et al., 1945; Dargent and Duroux, 1946; Pons-Tortella, 1947) in 1956, Davis et al., described a six-typed classification based on connections between terminal branches, and tried to unify the previous classifications in these six types. In 1987, Katz and Catalano proposed a more extended classification considering the buccal origin and the number of trunks of the facial nerve. The possibility of a double trunk was also studied by other authors (Kopuz et al., 1994). We can say that, observing different criteria previously proposed and based on our results, there are twelve different patterns. Therefore, the new classification proposed is based on three criteria: connections between terminal branches, buccal origin and number of facial nerve trunks (Table 4). Our results fit into the patterns described in this unified proposed classification. Figure 6 presents the boxplot analysis for each pattern type by author.

Surprisingly, there is a big variation in types II, III,V and VI percentage of cases reported by each author, whereas most of the authors reported similar percentage pattern types I and IV. Therefore, there is no pattern variation agreement.

This explains the need of a new classification, or at least, a change in the way we study the facial nerve to achieve a better knowledge for surgery.

Regarding clinical relevance, this new classification's usefulness may be controversial due to its high number of patterns. It does not really seem to have many advantages apart from

the fact that it gathers all the different patterns previously described in the literature. Therefore, we consider that, in clinical terms, it would be more useful to come back to classical descriptions of independent branches (temporal, zygomatic, buccal, mandibular and cervical), in number and path.

4. Connections between branches

Facial branches connections were first described as analogues of the mesenteric vessels arcades (Cruveilhier, 1867). It is well known that connections are more commonly found in the temporofacial division than in the cervicofacial, because, as it has been said previously in the literature, the upper division has a plexiform nature indeed, compared with the lower one (Pons-Tortella, 1947; Davis et al., 1956). Classifications have frequently showed these multiple connections that appear in the temporofacial division (Davis et al., 1956; Katz and Catalano, 1987; Kopuz et al., 1994), however there are fewer references for interconnections in the lower division (Bernstein and Nelson, 1984).

When we look to the midface, the complex arrangement of the buccal branch contains multiple connections especially with the zygomatic branch or the mandibular branch (Tzafetta and Terzis, 2010; Dhiwakar and Khan, 2016). In our study, zygomatico-buccal connections were also the most frequent (23 cases, 60.53%), followed by buccal-mandibular and temporal-zygomatic. According to lower division connections, fewer authors have observed a high prevalence (Lineaweaver et al., 1997; Salame et al., 2002). In our sample, it was an infrequent event, we had just one case (2.3%).

Regarding connections with other cranial nerves, classical anatomists wrote about the existence of facial-trigeminal connections (Hovelacque, 1927). These connections were studied

by more recent authors, who found periorbital connections between the infraorbital nerve and the zygomatic or buccal branches (Yang et al., 2013, Tansatit et al., 2016). Other authors found connections between the mental nerve and mandibular branches (Won et al., 2014). We also observed, in all cases, that a branch either from the zygomatic twig or a buccozygomatical plexus joins the infraorbitary nerve as it emerges from the infraorbitary foramen, and that the marginal branch connected with the mental nerve near the mental foramen.

CONCLUSION

After reviewing the literature, due to the great variability of the facial nerve, it is hard to find a unique classification valid for every case. We have proposed a new classification of 12 patterns, but we agree with the classical authors that preferred to describe the terminal branches observed rather than offering complex classifications, which could not fit exactly with every nerve observed.

Moreover, it is necessary to consider the possibility of multiple branches (specially the temporal branch), a plexiform arrangement in the midface (buccal or buccalzygomatic plexus), fewer twigs in the mandibular and cervical branches (therefore these twigs are usually more affected in surgery) and connections with the trigeminal nerve (infraorbitary and mental).

Studying the extracranial facial nerve in the parotid gland by regions or branches, is more useful to prevent the injury of a branch during surgery than a complex classification. These classifications are usually hard to memorize and less practical at the moment of dissection.

Knowing the variability and specific characteristics of each branch, will help the surgeon to identify risk points for dissection or clinical relevance of a damaged branch.

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Figure Legend

Figure 1. Disecction of the facial nerve after removal of the parotid gland to show the proximal divisions, temporofacial (tf) and cervicofacial (cf) and the terminal branches; temporal (t), zygomatic (z), buccal (b), mandibular (m) and cervical (c).

A. Left facial type 1. No connections between terminal branches. The buccal branch arises just from one of the proximal divisions.

B. Left facial type 8. A complex network of connections between temporal, zygomatic, buccal and mandibular branches: buccal-mandibular connection (bm), temporo-zygomatic connection (tz) zygomatic-buccal connection (zb).

C. Left facial type 9. A complex arrangement of connections between zygomatic and buccal branches: buccal-buccal connection (bb), zygomatic-buccal connection (zb). It shows also a buccal branch with a double origin.

Abbreviations: auriculotemporal nerve (atn), facial artery (fa), facial vein (fv), Parotid or Stensen (Stenon) duct (st), superficial temporal artery (tsa), superficial temporal vein (tsv)

Figure 2. Disecction of the facial nerve after removal of the parotid glandto show proximal divisions: temporofacial (tf) and cervicofacial (cf) and terminal branches: temporal (t), zygomatic (z), buccal (b), mandibular (m) and cervical (c). Different patterns of the facial nerve.

A.Right facial nerve type 4. A double mandibular branch, a zygomatic-buccal connection (zb) and a buccal-buccal connection (bb).

B. Left facial nerve type 3. The buccal branches arises from the cervicofacial division, there is a buccal-buccal connection (bb) and also a connection between the temporal and the zygomatic branches (tz).

C. Left facial nerve type 4, the buccal branch arises from the cervicofacial division and there is a connection between the zygomatic and the buccal branches (zb).

Abbreviations: facial artery (fa), facial vein (fv), masseter muscle (ma), parotid gland (pg), retromandibular vein (rmv), superficial temporal artery (tsa).

Figure 3. Disecction of the facial nerve after removal the parotid gland for showing proximal divisions: temporofacial (tf) and cervicofacial (cf) and terminal branches: temporal (t), zygomatic (z), buccal (b), mandibular (m) and cervical (c). Different patterns of the facial nerve.

A. Left facial nerve type 8. It shows a complex network of connections between bucal, mandibular (bm) and zygomatic branches (zb).

B. Right facial nerve type 11. A double trunk of the facial nerve. The accessory trunk (at) gives off the cervical branch and it is also connected by two branches with the common trunk of the buccal and the mandibular branches (*).

C. Right facial nerve type 9. It shows a connection between the temporal and zygomatic branches (tz). The zygomatic branch is also connected with the infraorbitary nerve (*).

Abbreviations: facial artery (fa), facial vein (fv), infraorbitary nerve (in), retromandibular vein (rmv), superficial temporal artery (tsa).

Figure 4. Illustration of the twelve types of the new classification.

Figure 5. Lateral left view of a connection between the facial nerve mandibular branch (m) and the mental nerve (mn) after emerging from the mental foramen (fm). Facial muscles have been sectioned and declined upwards.

Abbreviations: facial artery (fa), facial vein (fv), mandible (man).

Figure 6. Boxplot analysis for each pattern type by author. Each box represents the variation in types percentage's prevalence between different authors. Outliers in the sample are represented out of the box as circles or asterisks in the case of extreme anomalous cases. Results reported by McCormack et al 1945, Davis et al 1956, Bernstein et al 1984, Myint et al 1992, Park et al 1997, Kwak et al 2004, Weerapanta et al 2010, Gataa et al 2016 and ours have been included. Results reported by Weerapanta et al 2010 in pattern I and pattern III are out of range respect to the remaining authors, Kwak et al 2004 reported anomalous large percentage of type II variations, McCormack et al 1945 found an unusual large percentage of type IV variations whereas we found an unusual low percentage of type IV variations in relation with the remaining authors.

		Types of Davis						Types of Katz and Catalano									Types of Kopuz		
	N	I	II	III	IV	V	VI	IA	IB	II	IIIA	IIIB	IIIC	IVA	IVB	V	VA	VB	VC
Davis et al., 1956	350	44 (13%)	71 (20%)	99 (28%)	82 (24%)	32 (9%)	22 (6%)												
Bernstein et al., 1984	35	3 (9%)	3 (9%)	8 (25%)	7 (19%)	8 (22%)	6 (16%)												
Katz & Catalano, 1987	100							24 (24%)		14 (14%)		44 (44%)		14 (14%)		3 (3%)			
Myint et al., 1992	79	9 (11.4%)	12 (15.2%)	27 (34.2%)	15 (19%)	6 (7.6%)	10 (12.7%)												
Kopuz et al., 1994	50							12 (24%)		6 (12%)		7 (14%)		19 (38%)			3 (6%)	1 (2%)	2 (4%)
Park et al., 1997	111	7 (56.3%)	15 (13.5%)	37 (33.45)	26 (23.4%)	7 (6.3%)	19 (17.1%)												
Weerapant et al., 2010	100	1 (1%)	10 (10%)	20 (20%)	18 (18%)	29 (29%)	21 (21%)												
Gataa & Faris, 2016	43	7 (16.2%)	10 (23.2%)	13 (30.2%)	8 (18.6%)	2 (4.6%)	3 (6.9%)												

Table 1. Comparison of different patterns and types reported in the literature according with the three most popular classifications described.

Terminal branch	Number of branches					Mean and range	Standard deviation
	1	2	3	4	5		
temporal	6 (15.78)	17 (44.74)	12 (31.58)	2 (5.26)	1 (2.6)	2.34 (1 - 5)	0.9087
zygomatic	22 (57.89)	11 (28.94)	5 (13.16)	-	-	1.55 (1 - 3)	0.7240
buccal	29 (76.32)	5 (13.16)	4 (10.52)	-	-	1.34 (1 - 3)	0.6689
mandibular	32 (84.21)	6 (15.79)	-	-	-	1.16 (1 - 2)	0.3695
cervical	36 (94.74)	1 (2.6)	1 (2.6)	-	-	1.08 (1 - 3)	0.3588

Table 2. Number of terminal branches of the facial nerve observed at the anterior border of the parotid gland.

Terminal branches	Length (mm)	Diameter (mm)
temporal	30.1+-6.8995	0.94+-0.3282
zygomatic	38.03+-6.6427	1.002+-0.4598
buccal	37.88+-7.3333	0.99+-0.3962
mandibular	33.14+-8.9845	0.8+-0.3407
cervical	40.55+-12.7843	0.83+-0.1509

Table 3. Length and thick of the five terminal branches of the facial nerve with their standard deviation.

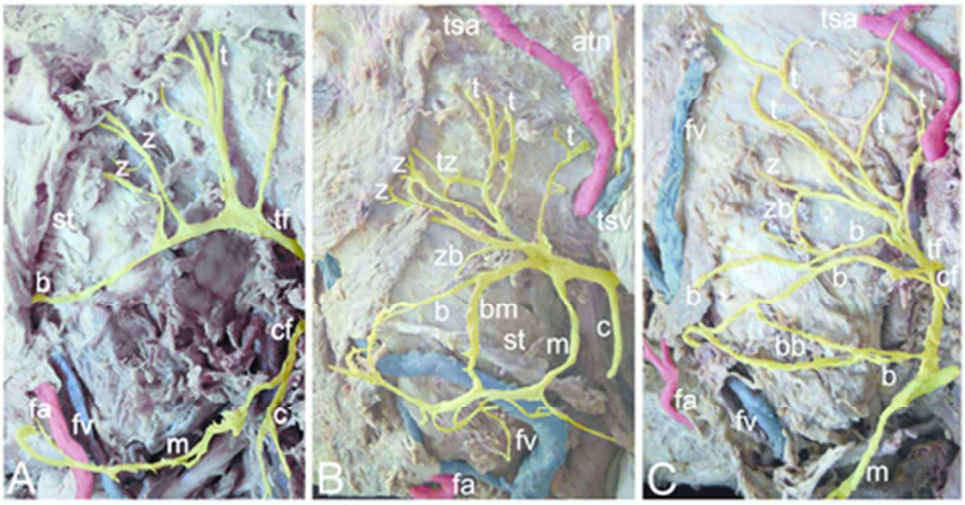
Types	Original classification	Name of the type in previous classification
1	Davis et al., 1956	I
2	Katz & Catalano, 1987	IB
3	Davis et al., 1956	II
4	Davis et al., 1956	III
5	Katz & Catalano, 1987	IIIC
6	Davis et al., 1956	IV
7	Davis et al., 1956	V
8	Davis et al., 1956	VI
9	Katz & Catalano, 1987	IVB
10	Kopuz et al., 1994	VA
11		VB
12		VC

Table 4. The new proposed classification in 12 types encloses every type reported in most popular classifications previously published.

Type 1: no connections.
Type 2: m side-connection,b originated from tf
Type 3: connections between temporofacial branches
a) z side-connection, b originated from cf. b) t-z. c) t-z-b if b originated from tf.
Type 4: one tf-cf connection, b originated from cf.
Type 5: b-m, b originated from tf.
Type 6: connections between tf branches and one tf-cf (t-z, z-z, z-b), b originated from cf.
Type 7: two tf-cf connections, b originated from cf.
Type 8: plexiform complex (t-z-b-m).
Type 9: plexiform complex (t-z-b-m), b originated from tf and cf.
Type 10: minor trunk joints tf.
Type 11: major trunk constitutes tf and minor trunk constitutes cf.
Type 12: minor trunk joints cf.

	Female				Male					
	Right		Left		Right		Left			
	n	%	n	%	n	%	n	%	n/N	%
type 1	2	22.2%	1	8.33	-	-	1	11.11	4/38	10.53%
type 2	-	-	-	-	-	-	-	-	-	-
type 3	3	33.33%	2	16.67%	1	12.5%	2	22.22%	8/38	21.05%
type 4	-	-	1	8.33%	2	25%	2	22.22%	5/38	13.16%
type 5	-	-	1	8.33%	2	25%	-	-	3/38	7.89%
type 6	-	-	1	8.33%	-	-	2	22.22%	3/38	7.89%
type 7	-	-	1	8.33%	-	-	-	-	1/38	2.63%
type 8	3	33.3%	2	16.67%	2	25%	1	11.11%	8/38	21.05%
type 9	-	-	2	16.67%	-	-	1	11.11%	3/38	7.89%
type 10	-	-	1	8.33%	-	-	-	-	1/38	2.63%
type 11	1	11.11%	-	-	-	-	-	-	1/38	2.63%
type 12	-	-	-	-	1	12.5%	-	-	1/38	2.63%
Total	9	100%	12	100%	8	100%	9	100%	38	100%

Table 5. Distribution by gender and side of the facial nerve in our sample according to the new 12 types proposed classification.



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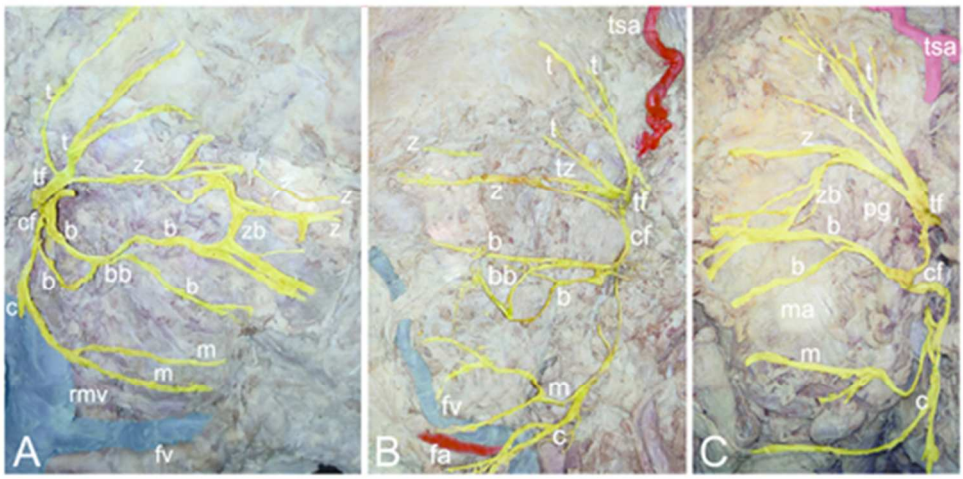

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Abbreviations: facial artery (fa), facial vein (fv), masseter muscle (ma), parotid gland (pg), retromandibular vein (rmv), superficial temporal artery (tsa).

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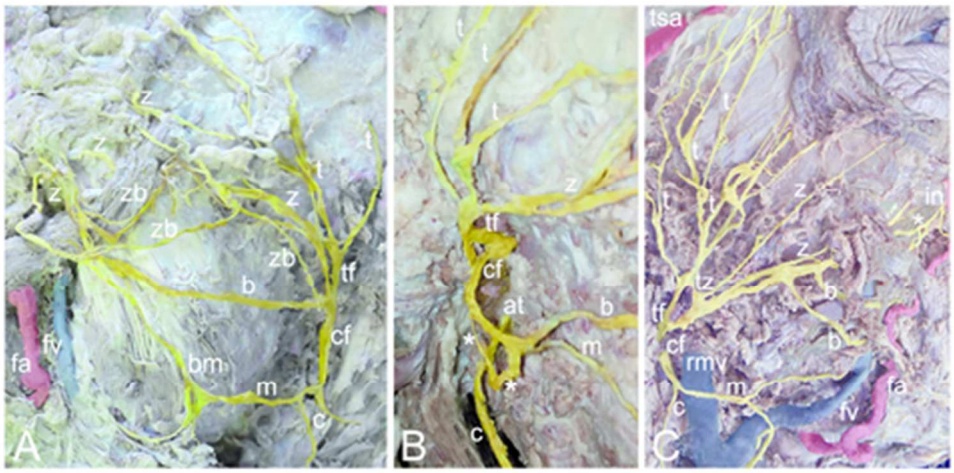

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Abbreviations: facial artery (fa), facial vein (fv), infraorbitary nerve (in), retromandibular vein (rmv), superficial temporal artery (tsa).

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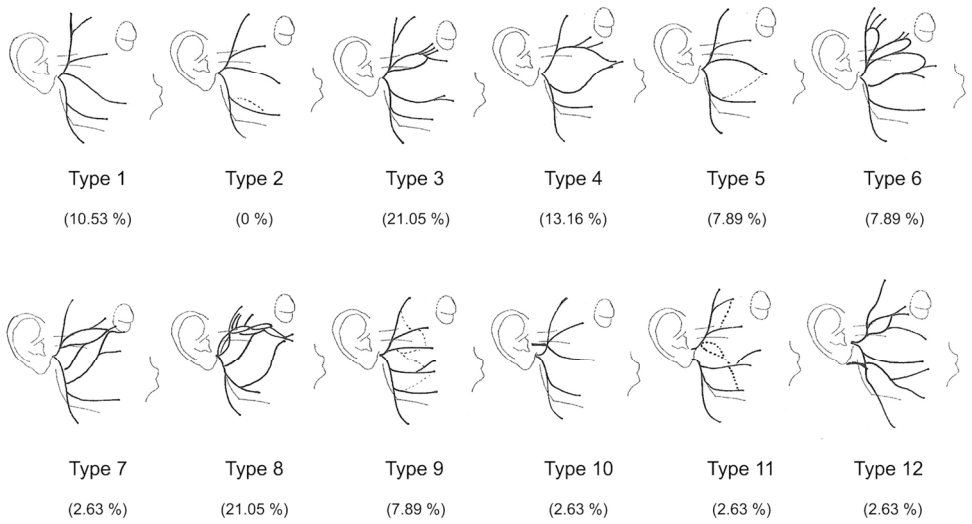

Figure 4. Illustration of the twelve types of the new classification.

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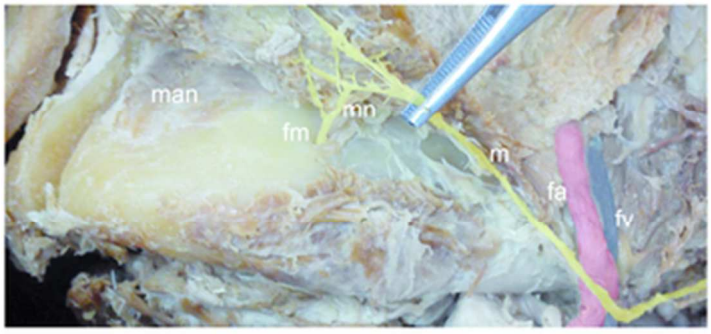

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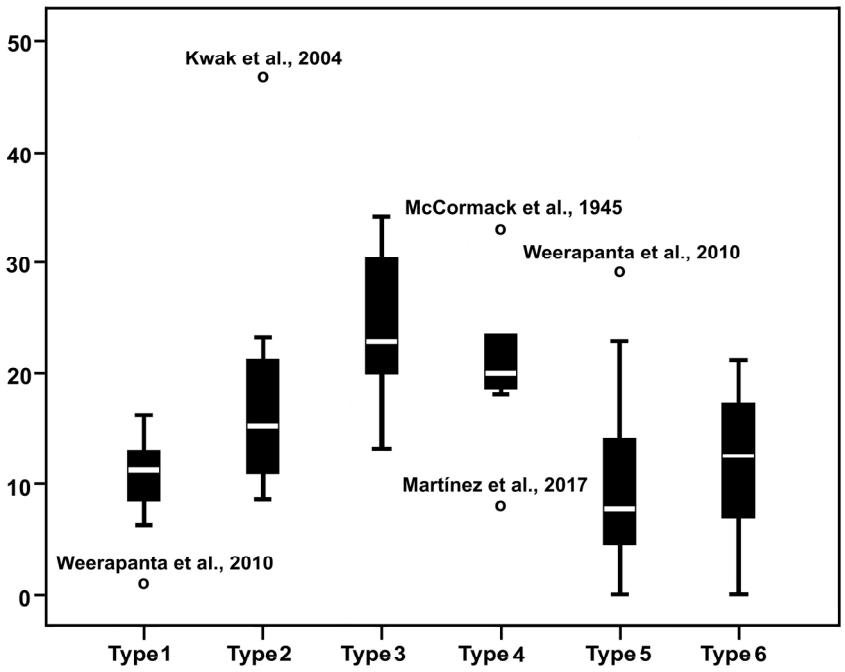

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