An Anatomic Study of the Facial Nerve Trunk and Branching Pattern in an African Population

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Abstract

There are known racial variations in the branching and furcation pattern and the length of the facial nerve (FN) trunk and hardly any studies from the black African population. Surgeries around the FN predispose it to trauma and warrant a detailed anatomy of its branching pattern. Using a descriptive cross-sectional study, a total of 40 FN (20 fresh cadavers) were dissected to record the pattern and length of the FN. The frequency of various patterns of FN using the Davis et al classification was as follows: type I: 10 (25%), type II: 9 (22.5%), type III: 7 (17.5%), type IV: 6 (15%), type V: 2 (5%), and type VI: 6 (15%). The nerve bifurcated in 32 (80%) and trifurcated in 8 (20%) of the cadavers. There was no statistical difference in the branching patterns (p = 0.509) and furcation types (p = 0.414) between the sides and gender. The length of the trunk of the FN measured from the stylomastoid foramen to the bifurcation point was 16.14 (± 3.28 mm). The results from this data established a variation in the anatomical branching pattern of the FN in a black Kenyan population.

Keywords► facial nerve
► branching and furcation pattern
► length
► African population

The arborization of the extratemporal facial nerve (FN) typically begins within the substance of the parotid gland and ultimately branches off the main trunk as the cervical, marginal mandibular, buccal, zygomatic, and frontal (or temporal) nerve.1 It emerges from the stylomastoid foramen in the base of the skull and immediately branches off the main trunk to the auricular muscles, the posterior belly of the digastric, and the stylohyoid muscles.2 The nerve then courses ventrally, and at the posterior edge of the parotid gland it splits into the upper and lower divisions.3 Within the gland, there is further branching with multiple individual variations.4–7 The upper (temporofacial) division of the FN gives off the temporal, zygomatic, and buccal branches, whereas the lower (cervicofacial) division gives off the marginal mandibular and cervical branches.4

Several studies have demonstrated variations in the branching patterns of the FN, bifurcation and trifurcation of the main trunk, reanastomosis, looping patterns, and morphometric variations in relation to surgical landmarks.2,5–14 Various classification systems of the FN have been used by different authors dating from 1945 by McCormack et al.,12 Dargent and Duroux (1946),13 Davis et al (1946),5 Baker and Conley (1979),14 Katz and Catalano (1987),9 Kopuz et al (1994),6 Tsai et al (2002),15 and Kwak et al (2004)2 to mention a few.2,5,6,9,12–15 Racial differences have been noted regarding the branching in FN in some studies. Davis et al in 194613 dissected 350 cadaveric facial halves and categorized the branching pattern of the FN into six distinct types.5 The FN trunk typically gave rise to superior/upper (temporofacial) and inferior/lower (cervicofacial) divisions. They noted that the marginal mandibular and cervical branches of the FN were exclusively derived from the inferior division, whereas the buccal branch always received some contribution from the inferior division and either none or a variable contribution from the superior division.5 There is a difference in the frequencies of branching patterns of FN using the Davis et al classification in studies from different countries.
in addition to variations in studies from the same country in populations groups. Three studies from the USA among Caucasian done by Davis et al, Bernstein and Nelson, and Katz and Catalano found type III to be most frequent. Among the Caucasians, the second most common was type IV according to Davis et al and type V according to Bernstein and Nelson, while Katz and Catalano found type I to be the second frequent. Types V and VI were the least according to Davis et al and Bernstein and Nelson, respectively, and Katz and Catalano did not report any type VI and the type V was the least in occurrence in his study population. Similarly, studies from India and Pakistan, by Malik et al and Khaliq et al, had higher percentages of types I and III, while types V and VI were rare. Rana et al, from Pakistan, observed type IIs and IV to be the most common and type VI was the least in occurrence in his study population. The differences in the frequencies are probably due to population from various racial background which renders comparisons between different studies with populations complex.

Salame et al emphasized the importance of the length of the FN trunk, since a segment needs to be sufficiently long to permit anastomosis with the fewest possible manipulations and neither too tense nor too loose. The FN trunk being dissected and manipulated between the exit from the cranial area and the functional importance of the branches of the FN may be located 21 mm below the skin. The anatomic pathways followed by the FN and its branches are very important and carry great significance for anatomists, surgeons, and clinicians to make accurate diagnosis and effective surgical intervention. The choice of the surgical approach in parotid surgery is particularly relevant because of the extreme anatomic variability of the parotid area and the functional importance of the branches of the FN. Preservation of the FN during parotid gland surgery depends on its being located without suffering damage. Accurate knowledge of the anatomy of the nerve and considerable perioperative care is essential if trauma is to be avoided. Comprehensive understanding of the anatomy of the FN is important in surgery involving the parotid gland, temporomandibular joint, craniofacial trauma, and mastoid bone surgery among others. Correct surgical approaches and identification of the FN trunk and its branches are critical in the avoidance of any iatrogenic injuries. Variant anatomy of the FN in different individuals and populations has been described in the literature, as well as racial differences, the aim of this study was to document the different anatomic variations with relation to the branching pattern and length of the FN trunk in a black African population in Kenya.

Materials and Methods

This was a descriptive cross-sectional study design, conducted at the Kenyatta National Hospital mortuary. The hospital is the largest public referral hospital serving the whole country of an African population which is predominantly of the black racial background. It is a teaching hospital in collaboration with the University of Nairobi. Ethical approval was obtained from the Kenyatta National Hospital/University of Nairobi Ethics and Research Committee (P112/03/2014). Informed consent was sought from the next of kin prior to the autopsy.

Convenient sampling of cadavers presented for postmortem in the mortuary was selected; they were all well preserved and refrigerated fresh with no tissue fixation or embalming. All cadavers that met the inclusion criteria were selected. Sample size was calculated using the following formula proposed by Varkevisser et al using variance and a sample size of 40 (20 cadavers) was calculated. The inclusion criteria were all well processed and preserved fresh adult cadavers. The exclusion criteria were any cadaver with facial malformations, pathologies, and traumatic injuries of the head and neck region in addition to those whose relatives did not consent.

Facial dissection of cadavers using a standard dissection kit was done during post mortem. The FN was exposed using a standard coronal incision during autopsy. These are incisions used for neck dissection and craniotomies to expose the skull and brain during autopsies. A mastoid to mastoid incision for craniotomy which joins the U-shaped cervical bone surgery among others. Correct surgical approaches and identification of the FN trunk and its branches are critical in the avoidance of any iatrogenic injuries. Variant anatomy of the FN in different individuals and populations has been described in the literature, as well as racial differences, the aim of this study was to document the different anatomic variations with relation to the branching pattern and length of the FN trunk in a black African population in Kenya.

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incision along the lateral aspect of the neck beginning from behind the ears and beyond the hairline to conceal the scar and avoid facial disfigurement was made. A flap was raised with an incision through the external auditory meatus with advancement anteriorly. The mastoid was identified and dissection proceeded to identify the FN using the surgical landmarks. The nerve was followed from its exit at the stylomastoid foramen to its furcation. The length of the FN trunk from the stylomastoid foramen to its furcation was measured using a caliper in millimeters. A superficial parotidectomy was done to expose its branches up to the anterior border of the masseter. Branching patterns were recorded in terms of the number of branches from the main trunk and final divisions pattern based on the classification by Davis et al. Identification of fine microscopic branches and their anastomosis was quite challenging. To assess intraobserver variability, every fifth specimen was measured twice and repeat measurement was done by the resident pathologist conducting the autopsies as well as the second co-author (F.M.B.). Meticulous closure of the incisions was done. Data was coded and analyzed using the SPSS version 18.0 software (IBM Inc.). Descriptive analysis was done and figures. Statistical tests (Students t-test, Wilcoxon signed-rank, and Mann–Whitney U test) were done to determine if the difference was significant between males and females, right and left FNs. Differences between dependent and independent variables were analyzed using the Spearman rank order correlation and Pearson’s product moment correlation. The significance level was set at \( p < 0.05 \).

**Results**

Twenty fresh cadavers were dissected (40 FNs) among which 12 (60%) were male and 8 (40%) were females (M:F = 3:2). All the various patterns according to Davis et al were present in the study population (\( \text{Fig. 1A–D} \)). The frequency of the pattern was type I (25%), type II (22.5%), type III (17.5%), type IV and VI (15%), and type V (5%). Eleven (55%) of the cadavers had similar branching patterns between the right and the left sides, while 9 (45%) had dissimilar patterns. Comparison of the branching pattern was done between the genders and Kruskal–Wallis H test showed that there was a no statistically significant difference in the branching patterns between the genders (\( \chi^2(1) = 1.127, p = 0.288 \)). Type I had no anastomosis between the branches, while type VI had the most intricate pattern with anastomosis among all the branches except the cervical. On comparison between the branching patterns on the right with the left sides, a Wilcoxon signed-rank test did not elicit any statistically significant change between the left- and right-side branching pattern (\( Z = -0.660, p = 0.509 \)); however, the Spearman’s rank-order correlation showed a positive correlation between the left- and right-side branching pattern which was statistically significant (\( r_s = 0.643, p = 0.002 \)).

The FN trunk was found to branch into two (bifurcation) in 32 (80%) of the cases and three (trifurcation) in 8 (20%) of the cases. No case of quadrification was noted in this study. In males, 19 (79%) of the FNs bifurcated, while 5 (20.8%) trifurcated (\( n = 24 \)). In females, 13 (81.25%) FNs bifurcated, while 3 (18.75%) trifurcated (\( n = 16 \)). One case of a minor trunk emerging from the stylomastoid foramen was observed which anastomosed with the temporal branch of the FN. (\( \text{Fig. 2} \)). Fourteen 14(70%) cadavers had similar furcation type of the trunk between the right and left sides, while 6 (30%) had different types. A Spearman’s rank-order correlation was used to determine the relationship between the left-side bifurcation of the main trunk and the right-side bifurcation of the main trunk. There was a positive correlation between the left- and right-side bifurcation of the main trunk which was not statistically significant (\( r_s = 0.081, p = 0.735 \)). The Pearson correlation test between the left- and right-side variables showed that there was a positive correlation which was statistically significant in the length of the trunk (\( p = 0.414 \)). The Wilcoxon signed-rank test found no statistical significance between the left- and right-side bifurcation of the main trunk (\( Z = 0.816, p = 0.414 \)) (\( \text{Table 2} \)).

The mean lengths of the trunk were closely related between the two sides with a mean on the right of having been 16.15 mm compared with 16.13 mm on the left side. Independent samples t-test was used to analyze the difference of the various measurements across the genders. The results showed no statistically significant differences in the length of the trunk and between the genders.

**Discussion**

**Branching Patterns**

Earlier studies by Davis et al in 1946 showed the highest frequency of mainly the type III (28%) pattern which is similar to other studies done in Caucasians, Arabs, Malaysians, and Koreans. Our study found type I (25%) as the most frequent type documented by other studies done in India and Pakistan. In other reports from Thailand and India, types II and V were the highest, respectively. Type I, the classical textbook pattern, was found to have been one of the least common patterns, which was not the case in this population. The second most frequent in our population was type II (22.5%), like in Iraqi study. Other studies from USA, Korea, Malaysia, and India had types I, IV, and V as the second common. The third in place were types II, III, IV, and VI as was the observation in our population. The branching pattern types VI, I, II, and V were the least frequent among Caucasians Indians, Pakistanis, Thai, Koreans, Malaysians, and Arab similar to our study. Types IV and VI occurred at the same frequency (15%) with the least being type V (5%) (\( \text{Table 1} \)). Most studies did not find a significant difference between the right and left branching pattern of the FN. Type V, although showing extensive anastomosis in the upper part of the face, has no additional contribution to the mandibular branch. Thus, surgeons should take precaution in surgery of the mandibular region. Type VI has the most complicated pattern with anastomosis between every branch, except the cervical one. This complex anastomotic pattern would lead to less...
incidences of facial paralysis in case of iatrogenic injury to any of the branches; however, this being not a frequent pattern in our cadavers, caution is, therefore, exercised during parotid surgery when exposing the FN. Very few studies have attempted to compare the incidence of FN paralysis following damage to the branches and branching types. Temporal and mandibular branches of the FN are most prone to injury because they rarely have any anastomosis with other branches of the nerve.\textsuperscript{23} Racial differences have been demonstrated in frequencies of various types between Asians and Caucasians.\textsuperscript{7,23,25} Bilateral comparison for the FN branching pattern did not elicit any significant difference between the right and left sides.

Racial differences have been noted in some studies. In a Korean population, the results indicated that the communicating branches between the buccal and marginal
mandibular branches occurred more frequently in Koreans than Caucasians. In addition, Wang et al reported a 60% prevalence of these communicating branches in the Chinese, while Niccoli and Varandas reported 9% prevalence in Spanish cases. Myint et al in a Malaysian study found no significant difference in the percentage of each type between the Malaysian population and that of the Koreans, though some differences with Caucasians were noted in three uncommon types. When compared with the studies done in different races, the present study from a black African population shows that types I and II were the most frequent pattern while, Caucasian and Asian studies reported a higher frequency of type III. And type V was the least common similar to as reported by others. Kopuz et al in a study in a Turkish population also suggested that race may be an important factor in the branching of the nerve. Several authors have reported the possibilities of trifurcation, quadrifurcation, or even a plexiform branching pattern of the FN trunk by Davis et al and by others. Reports from Davis et al, Park and Lee, Katz and Catalano, Kopuz et al, Ekinci, Salame et al, Tsai et al, Kwak et al, and Rana et al 2012 from various racial groups including Caucasians, Koreans, Malaysians, Turkish, Thai, and Indians reported percentage of bifurcation ranging from 100 to 81.3%, similar to our finding of FN trunk bifurcation at 80%. Trifurcation in the present study was observed in 20% of the population like other studies from Turkey reporting trifurcation of 18.6, 18.8, and 18%, respectively. Khaliq et al in another study from Indian reported single trunk of FN in 95 and 8.57% of bifurcation, while Rana et al reported single trunk (2%) and trifurcation (3%). With regard to furcation of the main trunk, 14 were similar, while 6 were not. There was no significant difference between the left- and right-side furcation types. The results from this study tally with Kopuz et al and Kalaycioglu et al on bilateral configurations. Previous studies had not attempted to correlate the bilateral configuration. This could be of surgical relevance in case of bilateral surgical procedures to predict the opposite side configurations. However, on furcation types, there was positive correlation which was not statistically significant ($r_s = 0.081, p = 0.735$). In an attempt to demonstrate the significance of these differences, an Iranian study suggested that variability in the branching patterns of the nerve creates variability in facial animation, both between patients and ethnic groups and between the sides of the face.

**Table 2** Distribution of branching patterns (Davis et al) by side

<table>
<thead>
<tr>
<th>Branching pattern</th>
<th>Right</th>
<th>Left</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>II</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>III</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>IV</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>V</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>VI</td>
<td>3</td>
<td>3</td>
</tr>
</tbody>
</table>

**Table 3** Wilcoxon signed rank test for branching patterns (Davis et al classification I to VI and bifurcation of the main trunk

<table>
<thead>
<tr>
<th>Side</th>
<th>Left</th>
<th>Right</th>
<th>−Ranks</th>
<th>+Ranks</th>
<th>Ties</th>
<th>Z</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Davis branching pattern</td>
<td>2.80</td>
<td>1.82</td>
<td>6</td>
<td>3</td>
<td>11</td>
<td>−0.660</td>
<td>0.509</td>
</tr>
<tr>
<td>Bifurcation of main trunk</td>
<td>2.15</td>
<td>.37</td>
<td>2</td>
<td>4</td>
<td>14</td>
<td>−0.816</td>
<td>0.414</td>
</tr>
</tbody>
</table>

Abbreviation: SD, standard deviation.
**Table 4** The percentage of bifurcation and trifurcation FN trunk by various studies

<table>
<thead>
<tr>
<th>Author</th>
<th>Racial Group</th>
<th>Single %</th>
<th>Bifurcation %</th>
<th>Trifurcation %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Davis et al, 1956&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Caucasians</td>
<td>100</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Park and Lee, 1976&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Korean</td>
<td>95.6</td>
<td>4.4</td>
<td>–</td>
</tr>
<tr>
<td>Katz and Catalano, 1987&lt;sup&gt;9&lt;/sup&gt;</td>
<td>Caucasian</td>
<td>100</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Myint et al, 1991&lt;sup&gt;21&lt;/sup&gt;</td>
<td>Malaysian</td>
<td>96.2</td>
<td>3.8</td>
<td>–</td>
</tr>
<tr>
<td>Kopuz et al, 1994&lt;sup&gt;5&lt;/sup&gt;</td>
<td>Turkey</td>
<td>82</td>
<td>18</td>
<td>–</td>
</tr>
<tr>
<td>Ekinci, 1999&lt;sup&gt;30&lt;/sup&gt;</td>
<td>Turkey</td>
<td>81.4</td>
<td>18.6</td>
<td>–</td>
</tr>
<tr>
<td>Salame et al, 2002&lt;sup&gt;20&lt;/sup&gt;</td>
<td>Korea</td>
<td>97.8</td>
<td>2.2</td>
<td>–</td>
</tr>
<tr>
<td>Tsai et al, 2002&lt;sup&gt;15&lt;/sup&gt;</td>
<td>Thailand</td>
<td>100</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>Kwak et al, 2004&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Korea</td>
<td>86.7</td>
<td>13.3</td>
<td>–</td>
</tr>
<tr>
<td>Kalaycioğlu et al, 2013&lt;sup&gt;31&lt;/sup&gt;</td>
<td>Turkey</td>
<td>81.3</td>
<td>18.8</td>
<td>–</td>
</tr>
<tr>
<td>Thuku et al, 2015</td>
<td>Kenya</td>
<td>80</td>
<td>20</td>
<td>–</td>
</tr>
<tr>
<td>Rana et al, 2017&lt;sup&gt;19&lt;/sup&gt;</td>
<td>Indian</td>
<td>2</td>
<td>95</td>
<td>3</td>
</tr>
<tr>
<td>Khalig et al, 2016&lt;sup&gt;18&lt;/sup&gt;</td>
<td>Indian</td>
<td>91.4</td>
<td>8.57</td>
<td>–</td>
</tr>
</tbody>
</table>

Abbreviation: FN, facial nerve.

**Length**

There are very few studies showing significant racial differences in FN trunk length. The length of the FN trunk in this population was found to have been 16.15±3.28 mm and there was no statistical difference between the right and left sides. Different authors have found varied lengths of the FN reported ranging from the shortest (13 mm) reported by Dargent and Duroux in 1946 (Switzerland) and Kwak et al in 2004 (Korea) to the longest (21 mm) reported by Holt in 1996 (USA).<sup>2,13,28</sup> The average length from the literature reviewed was 15.34 mm (Table 5). There were no statistical differences between the genders in keeping with previous studies.<sup>10,31</sup> The longest length were from USA (21 mm) and India (18.5 mm); in contrast, another study in USA reported the shortest length (9.38 mm).<sup>28,33,34</sup> The length of FN in our population was greater by 1 mm from the average identical to the study from Israel and India.<sup>17,20</sup> These differences in the length could partly be attributed to the nature of the different studies as some were on already fixed cadavers and others were on live patients during parotidectomies. The current study was on fresh cadavers and tissue changes were, therefore, minimal. Previous authors have emphasized the importance of knowledge of the FN trunk length and its relevance in performing surgical anastomosis and nerve grafts.<sup>20,33</sup> Salame et al emphasized the importance of the length of the FN trunk, since a segment needs to be sufficiently long to permit anastomosis with the fewest possible manipulations and neither too tense nor too loose.<sup>10</sup> Myint et al also found out that the distance from the bifurcation of the FN was shorter in the Malaysian population compared with studies done on Caucasian subjects.<sup>23</sup> They postulated that a longer distance between the bifurcation of the FN and the angle of the mandible in Caucasians could have been due to a larger stature, a bigger and stronger jaw or a combination of both factors in Caucasians when compared with Asians.<sup>23</sup> This is probably the similar explanation of having a longer length than average could be extended to the black Kenyan population in this study.

**Table 5** Length of the FN trunk in different studies

<table>
<thead>
<tr>
<th>Author</th>
<th>Country</th>
<th>Length (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dargent and Duroux, 1946&lt;sup&gt;14&lt;/sup&gt;</td>
<td>Switzerland</td>
<td>13</td>
</tr>
<tr>
<td>Holt, 1996&lt;sup&gt;28&lt;/sup&gt;</td>
<td>USA</td>
<td>21</td>
</tr>
<tr>
<td>Salame et al, 2002&lt;sup&gt;20&lt;/sup&gt;</td>
<td>Israel</td>
<td>16.44</td>
</tr>
<tr>
<td>Cannon et al, 2004&lt;sup&gt;34&lt;/sup&gt;</td>
<td>USA</td>
<td>9.38</td>
</tr>
<tr>
<td>Kwak et al, 2004&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Korea</td>
<td>13</td>
</tr>
<tr>
<td>Pather and Osman, 2006&lt;sup&gt;10&lt;/sup&gt;</td>
<td>Korea</td>
<td>14</td>
</tr>
<tr>
<td>Nishanthi et al, 2006&lt;sup&gt;13&lt;/sup&gt;</td>
<td>India</td>
<td>18.51</td>
</tr>
<tr>
<td>Thuku et al, 2015</td>
<td>Kenya</td>
<td>16.15</td>
</tr>
<tr>
<td>Malik et al, 2016&lt;sup&gt;17&lt;/sup&gt;</td>
<td>India</td>
<td>16.45</td>
</tr>
<tr>
<td>Average</td>
<td></td>
<td>15.34</td>
</tr>
</tbody>
</table>

Abbreviation: FN, facial nerve.

**Conclusion**

The current study establishes that FN trunk bifurcation and type I of Davis et al classification are the most common anatomical patterns of the extratemporal FN in a Kenyan African population.<sup>3</sup> The longer length of the trunk probably makes it more suitable for anastomosis during nerve grafting.

**Limitations**

As parts of the FN trunk formed curves, the caliper measurements may not be absolutely accurate; in addition, using a larger size probably provides better extrapolation of parameters to the African population.

Conflict of Interest

None.

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