Abstract

Introduction
Facial nerve injury may have devastating effects on function, aesthetics and the social interaction of the affected patients. Much energy has been devoted to reliably determining landmarks to predict the course of the facial nerve divisions. Yet there is little regarding reliability of various landmarks. The aim of this review was to discuss anatomic landmarks for localisation of the branches of the facial nerve.

Materials and Methods
A systematic literature review of English articles since 1990 was performed using search terms pertaining to facial nerve anatomy. In addition, data from our own anatomic studies are presented.

Results
A total of 320 articles were returned of which 17 met our criteria.

Discussion
Many articles utilised soft tissues as landmarks from which to predict the course of the facial nerve. By contrast, fixed bony landmarks are judged to be more reliable. Few studies have attempted to assess the reliability of identification of landmarks by independent raters. The facial nerve itself has a variable anatomy, making consistent landmarks difficult to identify.

Conclusion
Many different methods are presented to identify the course of the facial nerve but further work is required to produce reliable and accurate guidelines for localisation of this nerve.

Introduction
Facial nerve injury and subsequent paralysis of facial musculature following surgery involving the face, head and neck is one of the most feared complications by both surgeons and patients. Outcomes of facial nerve injury can be devastating for patients as paralysis of facial musculature has significant medical, cosmetic and psychological consequences. While many tools are used intraoperatively to reduce the risk of nerve injury, most surgeons continue to rely on anatomic landmarks for identification and protection of the facial nerve and its divisions. Anatomic landmarks which are fixed and can be reliably palpated prove most useful in this regard. However, a wide range of landmarks have been proposed in the literature and often due to historic reasons, some of the most widely used rely on soft tissue landmarks which are variable between individuals. Landmarks evaluated range from bony prominences such as the zygomatic arch, orbital rim, angle of mandible and mastoid process to soft tissue including the eyebrow, lateral canthus, lobule, nares and labial commissures.

The facial nerve has a complex course (Figure 1) from its origin at the stylomastoid foramen to its...
terminal branches. Coursing deep to the posterior belly of the digastric muscle, the facial nerve emerges posterior to the mandibular ramus and travels only a short distance through the substance of the parotid gland before branching into temporo-facial and cervicofacial divisions at the pes anserinus. The temporo-facial division subsequently divides into terminal temporal and zygomatic branches supplying muscles of the forehead and orbit. The lower cervicofacial division trifurcates into buccal, marginal mandibular and cervical branches supplying the muscles of the mid- and lower face. Previous research evaluating landmarks of the divisions of the facial nerve have mostly relied on cadaveric dissection and analysis in two dimensions. In our laboratory, we have employed new techniques for evaluating surface landmarks in three dimensions. Superficial topography of the face is captured using a high resolution laser scanner (FARO®; Figure 2). Multiple independent raters palpate and pin the anatomic landmarks being evaluated and their precise location in 3D space is captured using a Microscribe™ digitiser (Immersion Corp. San Jose, CA). Following dissection and identification of the nerve being evaluated, its course can be documented by carefully exposing and digitising it in short segments. Accurate measurements of the nerve course in relation to the landmark under evaluation can subsequently be made once the superficial topography and digitised data are imported into 3D computer graphics software (Autodesk®, Maya®, San Rafael, CA) using plugins developed in our laboratory. Therefore, using this methodology, more precise measurements can be obtained in 3D and compared across raters.

While the anatomy of the facial nerve has been extensively studied in the literature, a variety of anatomic landmarks have been identified with little consensus regarding those that are optimal and safest for use intraoperatively. The purpose of this paper is to review and evaluate the landmarks that are used for identification of the divisions of the facial nerve.

**Materials and Methods**

Studies were deemed eligible for review if the following criteria were met: A) Publication was after 1990 B) Published in English and C) Included quantitative measurements of nerve course. Studies were identified by searching MEDLINE and PUBMED databases using a set created with the search terms: ‘landmarks’, ‘facial nerve’, ‘mandibular nerve’, ‘buccal nerve’, ‘temporal nerve’, ‘frontotemporal nerve’, ‘frontal nerve’, ‘zygomatic nerve’, ‘cervical nerve’. Using the eligibility criteria and search terms, a total of 320 articles were identified, each was verified for suitability for inclusion to the study. In

![Figure 2: Three dimensional Modelling of facial nerve branches following digitization. The facial mask has been produced using a FARO® laser scanner. The branches of the facial nerve have been dissected under a dissection microscope and digitised using a Microscribe™ G2X Digitiser (Immersion Corp. San Jose, CA).](image-url)
Table 1 Landmarks used to identify main divisions of the facial nerve

<table>
<thead>
<tr>
<th>Reference</th>
<th>Landmark</th>
<th>Distance to nerve</th>
<th>Method</th>
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</thead>
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<tr>
<td><strong>Fronto-temporal branch</strong></td>
<td>Position of FTN measured with respect to line from lateral canthus to superior border of zygomatic arch</td>
<td>Posterior ramus (cm) 6.0 ± 0.4 Middle ramus (cm) 4.0 ± 0.6 Anterior ramus (cm) 3.8 ± 0.4</td>
<td>Embalmed cadaveric dissection (n = 30)</td>
</tr>
<tr>
<td>Trinei et al. (1998)</td>
<td>Sentinel vein; Junction of zygomatic arch and root of helix</td>
<td>Branch of FTN within 6.4 mm (2 – 9 mm) cephalad to sentinel vein; 24 mm (19 – 27 mm) anterior to junction of zygomatic arch and helix</td>
<td>Fresh cadaveric dissection (n = 20)</td>
</tr>
<tr>
<td>Schmidt et al. (2001)</td>
<td>Lateral canthus</td>
<td>2.85 ± 0.69cm (1.7 – 4.2 cm) superior to lateral canthus; 2.54 ± 0.43cm (2.0 – 3.1cm) lateral to lateral canthus</td>
<td>Embalmed cadaveric dissection (n = 10)</td>
</tr>
<tr>
<td>Miloro et al. (2007)</td>
<td>Most anterior aspect of external acoustic meatus</td>
<td>2.12 ± 0.21 cm (1.68–2.49cm) from most anterior aspect of external acoustic meatus to posterior ramus of FTN</td>
<td>MRI study (n = 30 patients)</td>
</tr>
<tr>
<td>Trussler et al. (2010)</td>
<td>Zygomatic arch</td>
<td>FTN observed to be protected by parotid-temporal fascia as it courses over the zygomatic arch</td>
<td>Fresh cadaveric dissection (n = 16)</td>
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<tr>
<td>Davies et al. (2013)</td>
<td>Porion, zygomatico-temporal and fronto-zygomatic sutures</td>
<td>Posterior ramus of FTN 17 ± 4mm (12 – 22mm) anterior to porion; Anterior ramus of FTN 17 ± 3mm and 12 ± 2mm posterior to zygomaticotemporal and frontozygomatic sutures, respectively.</td>
<td>Embalmed (n = 5) and fresh (n = 10) cadaveric dissection</td>
</tr>
<tr>
<td><strong>Zygomatic branch</strong></td>
<td>Saylam et al. (2006)</td>
<td>Anterior border of parotid gland, tragus and lateral palpebral commissure</td>
<td>30.71 mm (16.20 – 45.64 mm) from tragus to emergence of ZN at anterior parotid; 19.29 mm (5.70 – 28.72 mm) mean vertical distance from a point midway from tragus to lateral palpebral fissure</td>
</tr>
<tr>
<td>Alghoul et al. (2013)</td>
<td>Upper masseteric retaining ligament</td>
<td>Superior branch of ZN deep to sub-SMAS plane (4.07 ± 1.29 mm); Inferior branch more superficial to sub-SMAS plane (1.41 ± 0.95mm)</td>
<td>Embalmed cadaveric dissection (n = 22)</td>
</tr>
<tr>
<td>Dorafshar et al. (2013)</td>
<td>Root of helix and commissure of mouth</td>
<td>ZN was observed to be a mean distance of 2.31 mm (0 – 6mm) from a point midway between tragus and commissure of mouth</td>
<td>Fresh cadaveric dissection (n = 18)</td>
</tr>
<tr>
<td><strong>Buccal branch</strong></td>
<td>Pogrel et al. (1996)</td>
<td>Parotid duct</td>
<td>Point at which BN crossed parotid duct localised 2.3mm (1 – 6 mm) from anterior edge of parotid gland; When inferior to duct, BN is a vertical distance of 5.43 ± 6.5mm from the duct</td>
</tr>
<tr>
<td>Saylam et al. (2006)</td>
<td>Parotid duct and tragus</td>
<td>When branches of BN coursed inferior to duct, observed at 16.78 ± 13.20mm from anterior parotid edge; When branches of BN coursed superior to duct, observed at 18.18 ± 5.04mm from anterior parotid edge</td>
<td>Embalmed cadaveric dissection (n = 66)</td>
</tr>
<tr>
<td><strong>Marginal mandibular branch</strong></td>
<td>Potgieter et al. (2005)</td>
<td>Angle of mandible and facial artery</td>
<td>MMN observed median distance of 2.3 mm superior to angle of mandible; MMN median distance of 2.4 mm anterior to facial artery at inferior border of mandible; MMN median distance of 10.7 mm superior to a point 2 cm anterior to facial artery</td>
</tr>
<tr>
<td>Saylam et al. (2007)</td>
<td>Anterior border of parotid gland, angle of mandible and lobule of ear</td>
<td>Emergence of MMN at anterior border of parotid at level of mandibular angle in 29 specimens and 6.0 ± 3.3 mm (2.5 – 15.1 mm) superior to mandibular angle in 21 specimens; Mean distance of 39.9 ± 7.3mm (18.3 – 52.3 mm) from lobule of ear to emergence of MMB at parotid edge</td>
<td>Embalmed cadaveric dissection (n = 50)</td>
</tr>
</tbody>
</table>
addition, data from our own anatomic studies are presented.

**Results**

Based on criteria for inclusion, 17 studies were judged as suitable for review. Each article was reviewed to determine the total number of patients/specimens analysed, landmarks selected and the method of measurement. Data for each branch of the facial nerve was summarised for ease of analysis (Table 1).

**Discussion**

The authors have referenced some of their own studies in this review. These referenced studies have been conducted in accordance with the Declaration of Helsinki (1964), the protocols of these studies have been approved by the relevant ethics committees related to the institution in which they were performed. All human subjects, in these referenced studies, gave informed consent to participate in these studies.

**Frontotemporal branch**

Due to its high rates of injury and significant functional morbidity following injury, the fronto-temporal branch (FTN) has been extensively studied. The FTN is at high risk of injury during surgical procedures such as facelift, cutaneous surgery and bicornoral approaches for craniofacial surgical access. One of the most widely used clinical estimates of FTN course is Pitanguy’s line, defined by a line drawn from a point 0.5 cm inferior to the tragus to a point 1.5 cm superior and lateral to the eyebrow. While not within our inclusion criteria, Pitanguy’s line has been widely criticised by numerous authors due its reliance on soft tissue landmarks that are variable between individuals and its inability to predict nerve distribution.

Within our search criteria, a total of six studies evaluating the FTN of the facial nerve were found. Ishikawa attempted to define the distribution of the FTN in 30 cadaveric facial halves. The position of the various branches of the nerve was measured in relation to a line marked between the lateral canthus and superior border of the zygomatic arch. The mean distance from the lateral canthus to the anterior, middle and posterior rami of the FTN at the point where they crossed the superior border of the zygomatic arch was found to be 3.8 ± 0.4 cm, 4.0 ± 0.6 cm and 6.0 ± 0.4 cm, respectively.

Trinei et al., examined the course of the FTN in relation to the sentinel vein and zygomatic arch in 20 fresh cadaveric facial halves. The FTN was observed to be a mean distance of 6.4 mm cephalad to the sentinel vein and a mean distance of 24 mm anterior to the junction of the zygomatic arch and helix. This landmark is of particular use in endoscopic brow and temple-lifting procedures. Schmidt et al., examined the course of the FTN in the periorbital region in 10 formalin-fixed cadaveric facial halves. The FTN was observed to be a mean distance of 2.85 ± 0.69 cm superior to the lateral canthus and 2.54 ± 0.43 cm lateral to the lateral canthus. Miloro et al., examined the location of the FTN with respect to the external acoustic meatus, at the level of the superior zygomatic arch, in 30 patients using axial high resolution MRI. The mean distance from the most anterior aspect of the external acoustic meatus to the posterior ramus of the FTN was 2.12 ± 0.21 cm. Trussler et al., defined the course of the FTN as it crossed the zygomatic arch in 16 fresh cadaveric facial halves. The authors proposed that the FTN is protected by a fascial layer.

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that they termed parotid-temporal fascia, as it travels over the zygomatic arch. While no specific anatomic landmark was evaluated for localisation of the nerve, it was suggested that division of the superficial musculoaponeurotic system (SMAS), as occurs during high-SMAS face lifts, would be safe as the FTN was covered by the parotid-temporal fascia. Lastly, Davies et al., documented the course and distribution of the FTN in 15 cadaveric facial halves using 3D analysis. The posterior rami of the FTN were observed to be a mean distance of 17 ± 4mm anterior to the porion.

The anterior rami of the FTN were 17 ± 3mm and 12 ± 2mm posterior to the zygomaticotemporal and frontozygomatic sutures. Therefore, an area of potential injury to the FTN was defined by a triangular area bounded by a coronal line 12 mm anterior to the porion subtended by a line drawn through the two zygomatic sutures (Figure 3). Independent raters were used to assess the validity of these landmarks and consistently found that all functionally important branches of the FTN lay between these two lines. Therefore, when choosing a landmark for localising the FTN, it may be more accurate to rely on measurements made from fixed bony landmarks such as the zygomatic arch, porion and zygomatic sutures.

**Zygomatic branch**

Few studies have examined the zygomatic nerve (ZN) in relation to palpable landmarks. The ZN is rarely injured during approaches to the mid-face. However, in a study examining facial nerve injury following the use of coronal approaches for stabilisation of zygomatic fractures, the ZN was involved in 5.3% of 56 cases. By 3 months postoperatively, recovery from ZN injury was observed in all cases.

Three suitable studies examining the ZN of the facial nerve were identified. Saylam et al., studied the course of the ZN in 66 formalin fixed cadaveric facial halves. The location of the nerve was evaluated with respect to the anterior border of the parotid, the tragus and the lateral palpebral commissure. The nerve was found 30.71 mm from the tragus to the point of emergence of the ZN at the anterior edge of the parotid gland. The mean vertical distance to the ZN from a point midway from the tragus to the lateral palpebral commissure was 19.29 mm. A second study measured the distance from the ZN to the zygomatic and masseteric cutaneous ligaments in 22 hemifaces. The upper (superior) branch of the ZN was found between the main zygomatic and upper masseteric retaining ligaments and located deep (4.07 ± 1.29 mm) to the sub-SMAS plane. By contrast, the lower branch of the ZN was observed inferior to the upper masseteric retaining ligament or penetrated at the inferior margin. In contrast to the upper ZN, the lower ZN was located more superficially (1.41 ± 0.95 mm). The difficulty of using these ligaments as landmarks is that they are not detectable on the surface and therefore, their clinical utility is limited to the ability to

**Figure 3:** Dissection of the frontotemporal branch of the facial nerve illustrating the triangular area of danger bordered by the porion line (POL) and zygomatic sutural line (ZSL). POL, porion line; ZSL, zygomatic sutural line.

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Clearly identify these structures during facelift-type approaches. By contrast, during facial reanimation procedures determining a reliable landmark to direct one to the zygomatic branch that most likely creates the smile (by innervation of zygomaticus major and minor) is desirable to speed identification of this specific branch. Finally, one study attempted to define a single point at which the ZN, and its communicating branches with the buccal branch, could be localised. Zuker’s point, a point midway from the root of the helix to the commissure of the mouth, was demarcated on 18 fresh cadaveric hemifaces (Figure 4). The authors proposed that the ZN was observed within a mean distance of 2.31 mm from Zuker’s point. The only caveats of this study are that neurostimulation was not used to confirm that the nerve branch identified actually produced a smile and that it relies on soft tissue landmarks.

Regardless of the low rates of injury, a safe approach to the mid-face must be developed and caution must be exercised in areas where nerve injury is more probable. For example, the superficial location of the lower branch of the ZN, with respect to the upper masseteric retaining ligament, increases the likelihood of injury. Likewise, the prudent surgeon should be aware of the position of the ZN with respect to its location relative to the anterior edge of the parotid gland. Both of which are important in facelift surgeries. In addition, accurate localisation of the ZN is helpful during nerve mapping via nerve stimulation; this is of particular significance for those patients requiring facial reanimation. However, defined bony landmarks from which to navigate to the zygomatic branch remain to be characterised.

**Buccal branch**

Two studies evaluating landmarks for identification of the buccal branch of the facial nerve (BN) were found to be suitable for review. Both studies focused on the parotid duct as a landmark for localisation of the BN, itself a mobile soft tissue structure. Pogrel et al., examined the course of the BN in 20 cadaveric facial halves and noted the position of the BN relative to the parotid duct. In 17 of the specimens, a single nerve branch was observed, 15/20 (75%) of which coursed inferior to the parotid duct. The BN coursed superior to the duct in the remaining two specimens. However, in 3/20 specimens, two nerve branches were observed, one superior and the other inferior to the duct. The BN coursed a distance of 2.3 mm from the point of emergence at the anterior edge of the parotid gland to the point at which it crossed the duct.

When inferior to the duct, a vertical distance of 5.43 ± 3.65 mm was measured from the duct to the BN. The authors concluded that the duct should be visualised intraoperatively, then the BN is most likely to be found inferior and within 1 cm of the duct. While Saylam et al. documented the position of the BN relative to the parotid duct, they also measured the distance from the tragus to the point of emergence of the BN at the anterior edge of the parotid gland in 66 hemifacial formalin-fixed specimens. Only 21/66 (35%) of specimens were observed to have branches passing inferior to the duct, 16.78 ± 13.20 mm from point of emergence. In 25% of specimens, the BN coursed superior to the duct at a distance of 18.18 ± 5.04 mm from the anterior edge of the parotid gland. A diffuse plexus of nerves surrounding the duct was found in 26.7% of specimens. In the remaining 8/66 specimens, two independent branches were observed coursing superior and inferior to the duct. In all specimens, the BN was found to be 35.62 ± 7.11 mm from the tragus to the point of emergence at the anterior edge of the parotid gland. The authors noted that the BN was below a line drawn from the tragus to the ala nasi in all circumstances.

![Figure 4: Zuker’s point. Patient marked for cross face nerve grafting procedure. The palpable zygomatic arch is marked as is the pre-auricular incision. The dotted line represents the vector of the frontotemporal branch of the facial nerve. The cross indicates Zuker’s point (midway between the root of the helix and the oral commissure).](image-url)

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**For citation purposes:** Davies JC, Agur AMR, Fattah AY. Anatomic landmarks for localization of the branches of the facial nerve. OA Anatomy 2013 Dec 01;1(4):33.
A common area of injury to the BN is at its exit point from the parotid within the loose areolar sub-SMAS tissue anterior to the gland. Therefore, detailed knowledge of the course of the buccal branch relative to nearby structures, such as the parotid duct, is important in reducing the risk for nerve injury during procedures involving the mid-face. But in most surgical procedures, identification of the parotid duct is not performed. While discrepancy in the literature exists regarding the exact distribution of the BN either superior or inferior to the duct, it can be stated that the majority of branches will be observed inferior to the duct and two branches, superior and inferior to the duct, will be encountered only infrequently. As was suggested by Pogrel et al., when the BN courses inferior to the duct, it should be found within 1 cm of it. Like the zygomatic branch, no studies have attempted to relate the course of the buccal nerve with respect to bony landmarks.

Marginal mandibular branch

Injury to this branch has been reported following parotidectomy, rhytidectomy, reduction of mandibular angle fractures and other forms of surgery in the submandibular region. Since it is frequently encountered during various surgical approaches to the neck and has a variable course, the MMN has been extensively studied. Identification and protection of the MMN during surgical approaches to the neck is of utmost importance in retaining symmetric smile and functionality postoperatively. Based on inclusion criteria for our search, a total of four studies were reviewed. Landmarks used to localise the marginal mandibular branch of the facial nerve (MMN) included: the angle of the mandible, facial artery, inferior border of mandible, parotid edge, lobule, gonion, retromandibular vein and masseteric tuberosity of the mandible. The most frequently evaluated landmark was the angle of the mandible and related structures, the gonion and masseteric tuberosity. The MMN was observed to be a median distance of 2.3 mm anterior to the angle of the mandible, a mean distance of 3.33 mm inferior to the angle of the mandible, a mean of 3.4 ± 6.0 mm from the gonion to the point of emergence of the MMN at the edge of the parotid gland and approximately 3 cm anterior to the masseteric tuberosity. A common discrepancy in the literature surrounded the lowest observed position of the MMN with respect to the inferior border of the mandible which is of clinical value in planning of incisions. One of the earliest studies investigating the position of the MMN relative to the mandible in 100 cadaveric facial halves stated that the nerve passed above the inferior border of the mandible in 81% of specimens and below the border in the remaining 19%. By contrast, Baker observed in 50 specimens that the MMN was 1–2 cm below the inferior border of the mandible in almost all specimens. However, recent literature tends to agree that the MMN may be found almost equally distributed above and below the inferior border of the mandible, but never greater than 2 cm inferior to the mandible.

As a result, a commonly used rule of thumb in clinical practice is to place incisions either two-finger breadths or 2 cm, below the inferior border of the mandible. While most studies agree that the two fingerbreadth distance...
provides adequate clearance for the MMN, the nerve can be encountered within millimetres of this landmark and injury remains a common complication following neck dissections. A recent study examining the currently used landmarks with 3D analysis indicated that the MMN may be as close as 0.5 cm from the two-finger breadth line and that a poor intra-class correlation coefficient ($R = -0.20$) exists between raters. By contrast, in this series, branches of the MMN were identified more than 2 cm below the inferior border of the mandible. Therefore, it was proposed that a starting incision 3 cm or two finger’s breadth (an average of 35 mm) below the inferior border of the mandible provides a greater distance and consequently reduces the risk of nerve injury (Figure 5).

Cervical branch

The limited interest in studying the course and distribution of the cervical branch may be due to its low rates of injury and the insignificant functional consequence of paralysis of the platysma. In one study, cervical branch injury was observed in 34 of 2002 SMAS-platysma face lifts. This amounted to an overall rate of 1.7% and all affected patients are fully regained function within 3 weeks to 6 months following surgery. However, recent interest in the anatomy of the cervical branch is related to its increasing use in nerve reconstruction following brachial plexus injuries, neurectomy for treatment of pathologic platysmal movement and intentional denervation to reduce the amount of banding required in the neck during SMAS plication facelift. Of those studies that were found to be suitable for review, only two focused on landmarks relevant for localisation of the cervical branch of the facial nerve. The course of the cervical branch of the facial nerve in 110 formalin embalmed cadaveric facial halves was first examined. The nerve was found to be 0.83 ± 0.37 cm posterior to the gonion and did not cross the angle of the mandible in any specimen. As such, it was stated that incisions placed 2 cm posterior to the gonion will preserve the inferior parotid pole and the nerves, including the marginal mandibular and cervical branches, emerging from it. The authors also proposed a zone of danger in the neck which extends 3 cm below the mandibular angle and 4 cm below the mandibular notch, stretching forward to a vertical level in line with the premolar teeth. While these recommendations provide a useful guide to avoiding nerve injury, precise measurements of the nerve course inferior to the mandible were not obtained. In contrast, Chowdhry et al. measured the distance from the angle of the mandible inferiorly to the first branch of the cervical nerve in 16 fresh cadaveric facial halves. They proposed that the cervical branch could be found approximately 1 cm inferior to the angle of the mandible perpendicular to a line drawn from the mentum to the mastoid process (Figure 6). By dividing the length of the mentum to the mastoid process by the length of the mandibular ramus, the authors determined a normalised ratio of 1.83 ± 0.17 cm to account for variations in patient size.

Therefore, by considering the results of the aforementioned studies, the gonion and angle of mandible may be used as reliable landmarks during preoperative planning to identify or avoid injury to the cervical branch during retromandibular and submandibular approaches.

Conclusion

Navigation to the various branches of the facial nerve using anatomic landmarks remains challenging not least due to the variability in the arrangement of facial nerve anatomy. Soft tissue landmarks are often used but are mobile and are of variable morphology. Bony landmarks are more reliable but few have been described; fewer studies have attempted to assess the accuracy of identification of landmarks by independent raters. Many studies rely on linear measurements from landmarks to localise the nerve, yet patients vary in size and as all studies identified were performed on adult specimens, surgical procedures performed on children cannot use such measurements with confidence. Useful guides are presented in this review but further studies need to be performed to produce reliable and accurate landmarks for identifying facial nerve branches.

References

Review


