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Abstract

Background: The masseteric nerve is a valuable donor nerve in the management of facial paralysis, however its location is less familiar to surgeons because this motor nerve is not commonly exposed in other head and neck procedures. Current techniques for masseteric nerve identification rely on physical measurements from surface or bony landmarks that may be unpredictable across patient age, ethnicity and size. We sought to identify a rapid and minimally invasive technique based on surgical anatomy independent of intra-operative physical measurements.

Methods: A two phase fresh frozen cadaver study was performed followed by a clinical application that included 11 consecutive patients undergoing facial reanimation procedures between May 2012 and October 2012.

Results: Ten cadavers were dissected and 11 clinical applications are reported. In all dissections the masseteric nerve was identified through the newly described "Subzygomatic Triangle". This triangle is formed by the zygomatic arch superiorly, the temporomandibular joint posteriorly, and the frontal branch of the facial nerve inferiorly and anteriorly. This finding was consistent across patient ages (8-49 years) and ethnicities. Through using the short scar, minimal dissection approach described in the study, average time to nerve identification was 10.2 minutes during the clinical application.

Conclusion: The subzygomatic triangle is a consistent anatomic landmark for rapid, reliable and minimally invasive identification of the masseteric nerve. The use of the subzygomatic triangle obviates the need for extensive dissection and surgeon reliance upon soft tissue measurements that may vary between patients of different size, gender or ethnicity.

Introduction

The masseteric nerve is a valuable source for new neural input in the management of facial paralysis. In patients with reversible facial paralysis, the location of masseteric nerve provides the potential for a tension free anastomosis to the main trunk or peripheral branches of the facial nerve without the need for an interposition graft. In patients with irreversible facial paralysis, the masseteric nerve can adequately power transplanted free functional muscle flaps in a single stage reanimation procedure. In both cases, the masseteric nerve may be completely mobilized and transposed for an end-to-end neurorrhaphy without functional complications.^{1,2,3,4,5,6}

The masseteric nerve is not routinely identified in common head and neck operations. As such, surgeons generally have little clinical experience with masseteric nerve anatomy. Although the nerve's skull base anatomy and ramification pattern in the masseter muscle has been well described, few reports depict clinically applicable data for identifying the nerve during facial reanimation procedures.^{7,8} A very recent report describes the masseteric nerve location through a series of average measurements from the tragus and the zygomatic arch⁹. Although a valuable contribution to the literature, this masseteric nerve identification schema is reliant on physical measurements from surface or bony landmarks that may be unpredictable when considering the age, gender, ethnicity, size and general anatomic variability of a given patient.

As the masseteric nerve is a valuable asset to the facial reanimation surgeon, and because identifying the masseteric nerve is an uncommon exercise, we set out to identify a reliable means of masseteric nerve identification that does not rely upon soft tissue measurements and that is applicable to all patients. Additionally we sought to create an identification technique that is both rapid and minimally invasive.

Methods

Specimens

Ten fresh frozen cadaver heads were obtained from the Johns Hopkins Department of Anatomy. The specific cause of death for the cadavers was not known to the surgical team, however there was no history of head and neck surgery or trauma in any specimen. The age of death was also not known, but all cadavers were adult specimens. The set of cadavers included Caucasian (six specimens), African American (three specimens), and Asian (one specimen) ethnicities.

Surgeons

The dissections were performed by the senior author (K.O.B), the first author (R.M.C), and an Otolaryngology Head and Neck Surgery senior resident at our institution. All masseteric nerve transfers were performed under the supervision of the senior author (K.O.B.).

Design

To reliably identify the masseter nerve for clinical application in facial reanimation, we designed a two phase cadaveric dissection study on 10 fresh frozen head specimens.

Cadavers 1-5

In the first five fresh frozen cadaver heads, wide dissection with generous masseteric nerve exposure was performed. The location and course of the masseteric nerve was delineated relative to the adjacent bony anatomic landmarks – the temporomandibular joint, sigmoid notch, zygomatic arch, and malar eminence. The masseteric nerve location relative to the main trunk and the frontal branch of the facial nerve was also recorded. The depth of the masseteric nerve within the masseter muscle was measured. Photographs were taken to document our findings. (Figure 1). Based on observations made from these wide dissections, we developed a strategy to rapidly and reliably identify the masseteric nerve through a minimally invasive approach using a novel anatomic triangle.

Cadavers 6-10

In fresh frozen cadaver heads six through 10, the masseteric nerve was identified through a limited minimally invasive dissection based on a novel anatomic triangle identified during dissection of cadavers one through five. The time to identification was noted.

Clinical Application

The newly developed rapid, minimal dissection approach to the masseteric nerve was applied to 11 consecutive patients undergoing facial reanimation procedures between May 2012 and October 2012. Time to nerve identification defined as the duration of dissection between SMAS flap elevation and identification of the masseter nerve confirmed by direct visualization and stimulation of the nerve was measured.

Results

Cadavers 1-5

In all cadavers undergoing broad dissection the nerve was identified within the substance of the masseter muscle. In each specimen, the nerve was found to reliably bisect what we have defined as the *Subzygomatic Triangle*. This triangle is formed by the inferior border of the zygomatic arch superiorly, a vertical line through the anterior border of the temporomandibular joint posteriorly, and the frontal branch of the facial nerve inferiorly and anteriorly (Figure 1 and 2).

The masseteric nerve followed a line that begins at the angle of the subzygomatic triangle that is formed by the temporomandibular joint and zygomatic arch, and crosses the midpoint of the triangle base formed by frontal branch of the facial nerve (Figures 1-2). This relationship was consistent in all specimens.

Within the masseter muscle itself, the nerve was located in the deep muscle belly below a white fibrous fascia. The nerve was between 10mm and 15mm deep to the parotidomasseteric fascia. At this location, a dominant branch was identified.

The dominant branch of masseter nerve coursed obliquely within the substance of the muscle for approximately 2 to 3 cm in an anterior-posterior direction before branching out.

Cadavers 6-10

Based on the nerve's relationship, we designed an approach for rapid identification with minimal incision and dissection that we applied to cadavers six through ten. A modified mini-facelift type incision was created with an extension into the temporal hair tuft. The vertical incision extended in the preauricular crease with a retrotragal component and stopped just superior to the ear lobule. A subcutaneous flap was elevated from the zygomatic arch superiorly to the level of the lobule inferiorly. A short SMAS flap was elevated and the course of the frontal branch of the facial nerve was outlined. A marking pen was used to ink boundaries of subzygomatic triangle and the line of bisection along which the masseteric nerve travels as described above. The nerve was then easily identified along its inked course within the subzygomatic triangle after minimal blunt dissection within the substance of masseter muscle .

Clinical Application

We applied the subzygomatic triangle as a means of identifying the masseteric nerve in 11 consecutive patients undergoing facial reanimation between May 2012 and October 2012. Patient ages ranged from 8 to 49 and the series included Caucasian, Hispanic, Middle Eastern, Asian and African American patients (Table 1). The cases included masseteric nerve to buccal branch neurotizations, masseteric nerve to facial nerve main trunk neurotizations, and a masseteric nerve to obturator nerve neurotization for a single staged gracilis free functional flap.

The procedures were performed with a facial nerve monitor in place in those patients with partial facial paralysis. Neuromuscular blocking agents were avoided beyond the induction period for intubation. Local anesthetic agents were not employed limiting soft tissue infiltration to vasoconstricting agents only, using a 1:100,000 epinephrine solution. To outline the subzygomatic triangle, the inferior border of the zygomatic arch was outlined. This was joined by a vertical line through the anterior border of the temporomandibular joint. The location of temporomandibular joint was accurately identified by palpating the sigmoid notch or manually opening and closing the mandible. The anticipated course of the frontal branch of the facial nerve over the zygomatic arch completed the subzygomatic triangle.

Following skin flap elevation, a separate limited short SMAS flap was performed to expose the parotid fascia. The frontal branch of the facial nerve was easily identified using blunt dissection. The frontal branch was traced retrograde to the main facial nerve trunk when nerve anastomosis at that level was planned. Similarly, blunt dissection through the parotidomasseteric fascia was employed to identify the buccal branches when they are the target for nerve grafting.

With the facial nerve branches safely retracted, blunt dissection was carried out within the subzygomatic triangle into the substance of the masseter muscle. At the base of the subzygomatic triangle, the nerve was identified along a line bisecting the angle formed by the temporomandibular joint and zygomatic arch, as described above (Figure 3). We found that careful bipolar cautery through the masseter muscle fibers to the depth of the nerve with intermittent nerve stimulation allowed safe and nearly bloodless dissection. With this approach, the masseteric nerve was identified for the 11 clinical cases at a mean of 10.2 minutes (Table 1). Once identified, the masseter nerve was traced inferiorly approximately 2 to 3 cm until it arborized. It was then divided and transposed toward its target nerve. In all cases tension free neurorrhaphy was performed without interposition grafting. In addition, the limited incision and exposure was adequate for identifying the masseter and facial nerves and for neurorrhaphy under microscopic magnification. There were no significant cases of post-operative trismus .

Discussion

This study describes a novel anatomic triangle that reliably predicts masseteric nerve location without reliance on measurements from soft tissue and bony landmarks. The subzygomatic triangle predicted the location of the masseteric nerve in ten consecutive cadaveric dissections, and 11 patients of all age groups undergoing a myriad of facial reanimation procedures, with a mean time to masseteric nerve identification of 10.2 minutes.

Anatomic Considerations

The masseteric nerve is a motor branch of the third division of the trigeminal nerve. The mandibular nerve exits the skull base through the foramen ovale, and the masseteric nerve leaves the mandibular nerve shortly after its entrance into the infratemporal fossa. The masseteric nerve is the largest motor branch of the trigeminal nerve averaging 2mm in diameter⁷. It passes superior to the lateral pterygoid muscle and exits the infratemporal fossa through the mandibular notch, also called the sigmoid notch, accompanied by the masseteric artery. There are approximately one to five branches of the nerve at the entrance into the masseter muscle with one dominant branch¹⁰.

The subzygomatic triangle overlies the entrance of the masseteric nerve from the infratemporal fossa into the masseter muscle and outlines a limited and condensed area within which the nerve can be identified without the need for extensive exposure and muscle fiber dissection. The probability of finding this small sized nerve is greatly enhanced when dissection is confined to this defined triangle as compared to an expanded field requiring more muscle fiber dissection. One can visualize the nerve traveling retrograde within the masseter muscle as if funneling to the base of the subzygomatic triangle – from its broad inconsistent ramified state in the substance of the muscle toward its narrow consistent location as it exits the muscle toward the infratemporal fossa and ultimately the foramen ovale (Figure 2A-B). The optimized efficiency and reliability in locating the masseteric nerve within subzygomatic triangle is supported by our cadaver dissection series and clinical application.

Efficient, Consistent, and Minimally Invasive

During the clinical application of the study, the average time to masseteric nerve identification was 10.2 minutes. Although the study was not designed to specifically compare efficiency in the clinical setting before and after introduction of the new approach, our overall case times for masseteric nerve transfer were markedly reduced with the implementation of this approach (data not reported).

Notably we successfully applied this approach to both adult and pediatric patients. The relationship of the masseteric nerve to the subzygomatic triangle was consistent across age, gender and ethnicities.

Finally, the approach required only a modified short scar facelift incision ending at the level of the lobule and minimal soft tissue dissection. Because the nerve is identified superiorly at the subzygomatic triangle, there is no need to extend the incision anteriorly into the neck nor extend the dissection broadly over the parotid and masseter muscle unless otherwise indicated for the procedure. Since disruption of the parotid is minimal no volume loss or sialoceles were encountered in this clinical series.

Study Strength

This study describes a novel anatomic triangle that reliably predicts the location of the masseteric nerve without the need for surgeon reliance upon soft tissue measurements. Previous publications addressing the location of the masseter nerve have relied heavily on surface measurements. While surface measurements are a useful guide, they do not account for the variability in facial shapes and head size that may vary with ethnicity and age particularly when considering children. Facial measurements also do not provide a palpable landmark that can serve as a constant reference point during the dissection. Our cadaver dissection series and group of patients undergoing facial reanimation procedures included a child, men and women aged 8 to 49 of multiple ethnic backgrounds. The masseteric nerve's simple anatomic relationship to the *subzygomatic triangle* was consistent in all cases.

Study weakness

This cadaver study and case series represents a relatively small number of dissections. A larger sample size would provide additional support for the relationship we identified in twenty-one consecutive dissections.

A potential confounder to the nerve identification efficiency we report is the practice effect, or learning effect. Due to repeating the task alone in the lab, one's ability to complete the task with greater efficiency may be enhanced. To the contrary, in the clinical application component of our study, a board eligible Otolaryngology Head and Neck Surgeon without past involvement in our cadaver dissections, nor previous clinical experience with masseteric nerve identification, was able to independently identify the nerve using the subzygomatic triangle principles with comparable efficiency.

Conclusion

The *subzygomatic triangle*, defined as the triangle formed by the temporomandibular joint, zygomatic arch, and frontal branch of the facial nerve, is a reliable anatomic landmark for rapid, reliable and minimally invasive identification of the masseteric nerve. The use of the subzygomatic triangle obviates the need for extensive dissection and surgeon reliance upon soft tissue measurements that may vary between patients of different size, gender or ethnicity.

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Figure Legend

Figure 1: Representative from cadaver one through five, with wide dissection allowing masseteric nerve exposure. 1: Frontal branch of facial nerve; 2: Course of masseteric nerve bisecting the base of the subzygomatic triangle; 3: Zygomatic arch; 4: Temporomandibular joint; 5: pre-auricular incision.

Figure 2A-B: Illustrations of the subzygomatic triangle demonstrating the masseteric nerve at its location within the subzygomatic triangle. Note the nerve is identified near the apex of the triangle. Yellow A = frontal branch of facial n; Blue B = temporomandibular joint; red C = Zygomatic Arch; black asterisk = masseteric nerve

Figure 3A-C: A) Preoperative markings showing the palpated zygomatic arch, temporomandibular joint, and anticipated course of the frontal branch of the facial nerve marked with ink; the subzygomatic triangle is indicated by dashed lines. B) Intraoperative photograph showing the subzygomatic triangle delineated by the temporomandibular joint (1), the zygomatic arch (2), and the frontal branch of the facial nerve (3). The yellow nerve loop extends deep the masseteric nerve deep in the dissection (4). Note that it bisects the base of the subzygomatic triangle. C) Post operative appearance showing minimally invasive incisions.

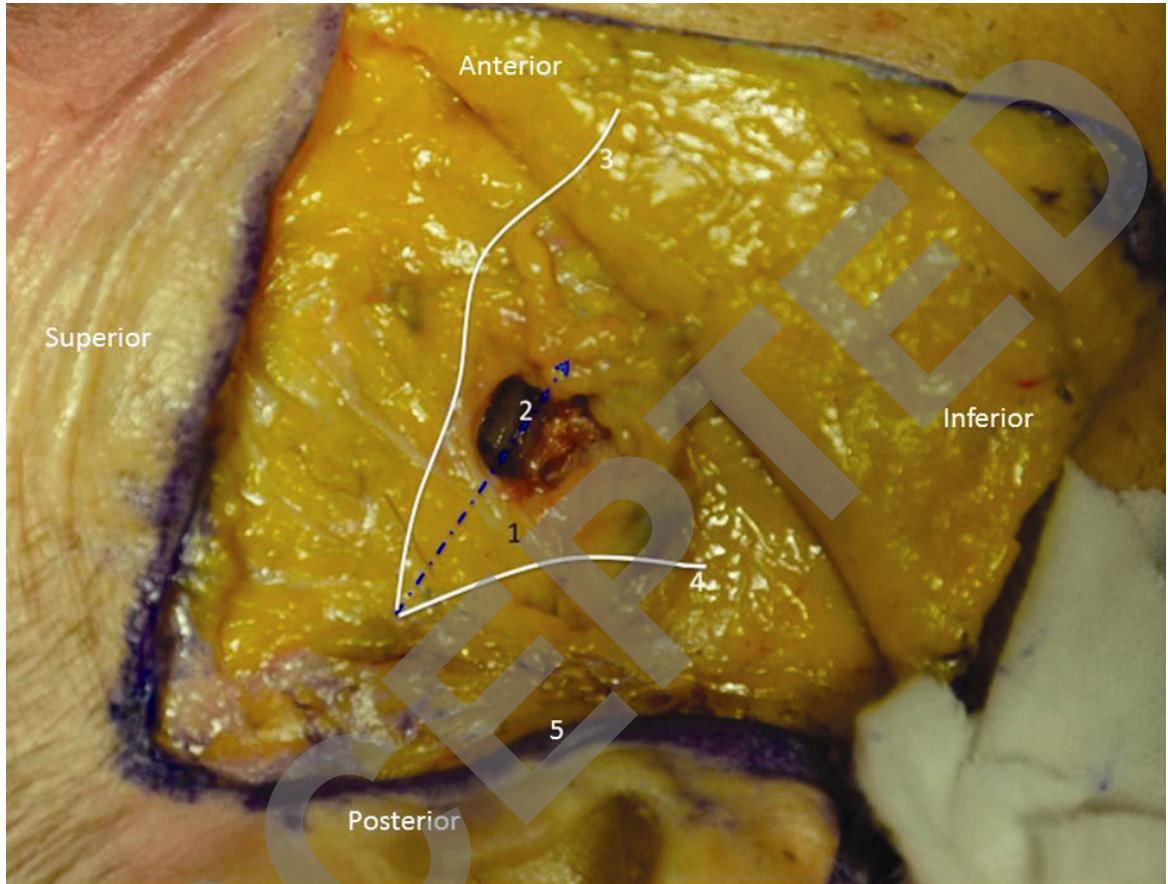
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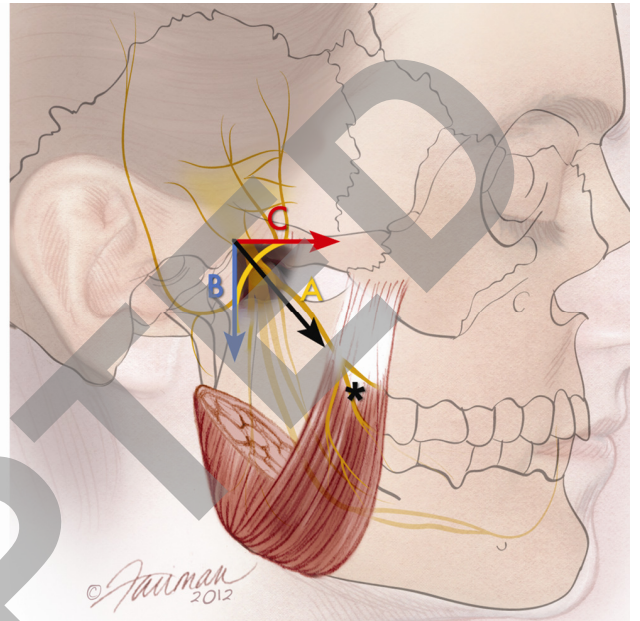
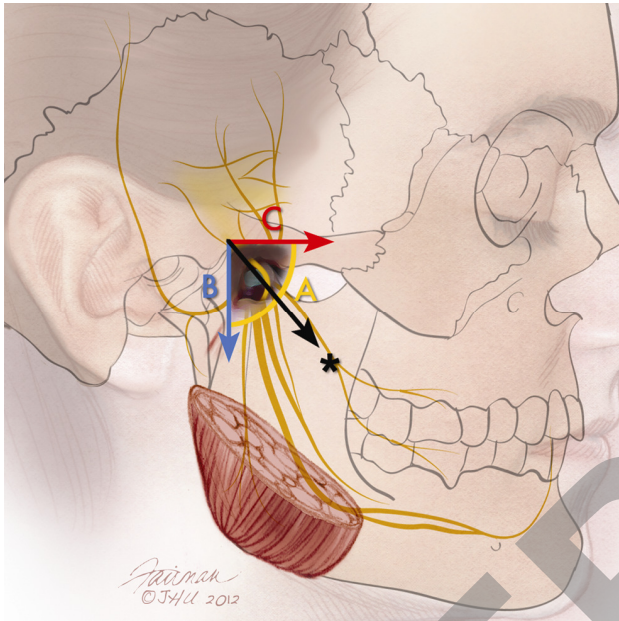
Table 1: Patient data from Clinical Application phase of the study, including age, gender, ethnicity, and time to masseteric nerve identification.

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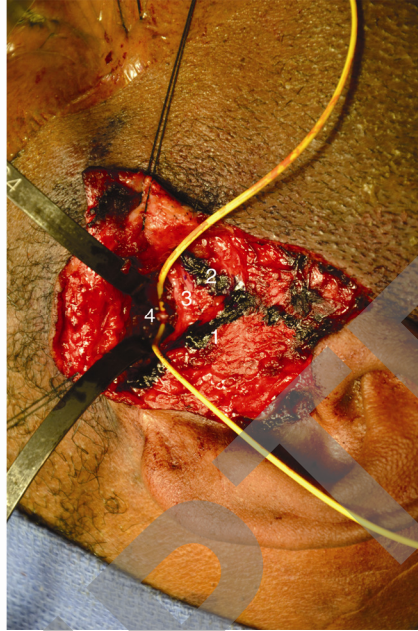
Age	Gender	Ethnicity	Time to Nerve Identification
49	M	African American	12
41	F	Caucasian	10
30	F	Caucasian	12
28	F	Caucasian	7
19	F	Caucasian	8
8	M	Hispanic	10
19	M	African American	11
32	F	Asian	11
36	F	Hispanic	12
41	M	Caucasian	10
32	F	Middle Eastern	9

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