Cutaneous Depth of the Supraorbital Nerve: A Cadaveric Anatomic Study With Clinical Applications to Dermatology

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BACKGROUND Common dermatologic procedures performed on the forehead may injure the supraorbital nerve (SON) leading to adverse outcomes.

OBJECTIVE To describe SON anatomic course and cutaneous depth.

MATERIALS AND METHODS Sixteen cadaver specimens were dissected.

RESULTS The supraorbital nerve originated 2.63 ± 0.27 (range, 2.1–3.5) cm from the midline and 0.25 ± 0.16 (range, 0–0.5) cm above the orbital rim. Supraorbital nerve emerged as 1 root dividing into superficial (SON-S) and deep (SON-D) branches. The supraorbital nerve deep branch remained deep to the aponeurosis of the corrugator supercilii and frontalis muscles and coursed laterally toward the scalp. Supraorbital nerve superficial branch emerged nearly perpendicular to the orbital rim and traveled under the corrugator supercilii with an average depth of 0.75 ± 0.16 (range, 0.5–1.1) cm. Supraorbital nerve superficial branches entered the subfrontalis plane at a mean distance of 1.29 ± 0.20 (range, 1.0–1.8) cm above the orbital rim with an average depth of 0.45 ± 0.13 (range, 0.3–0.8) cm. These branches entered the subcutaneous plane by piercing through the frontalis muscle at a mean distance of 2.60 ± 0.32 (range, 1.9–3.2) cm above the orbital rim with an average depth of 0.30 ± 0.10 (range, 0.2–0.6) cm.

CONCLUSION The supraorbital nerve depth and course are relevant when performing procedures on the forehead. A thorough understanding of the anatomy and depth of SON-S is critical to help minimize nerve damage and optimize patient counseling.

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The supraorbital nerve (SON) originates from the frontal branch of the trigeminal nerve and supplies the majority of sensory innervation to the forehead, upper eyelid, frontoparietal, and vertex scalp.[1,2] Many common dermatologic procedures, including punch biopsy, excision, and Mohs micrographic surgery can potentially damage the SON due to its relatively superficial depth. Supraorbital nerve damage can lead to complications such as paresthesia and neuroma formation.[3,4] Previous cadaver studies describe in detail the anatomic course of the SON.[1,2,5–7] The frontal nerve, a branch of the ophthalmic division of the trigeminal nerve, divides within the orbit to give rise to the SON and the smaller supratrochlear nerve. The SON emerges from the superior orbital rim through a notch or foramen, often a few millimeters above the palpable orbital rim. The SON then divides into a superficial branch (SON-S) and deep branch (SON-D). The SON-S travels nearly perpendicular to the superior orbital rim beneath the corrugator supercilii, eventually emerging into the plane beneath the frontalis by piercing through the corrugator supercilii directly or traveling beneath the corrugator supercilii and emerging from the superior border of the muscle. As the SON-S travels cranially, multiple branches fan out and penetrate the frontalis muscle to course through the subcutaneous plane providing

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sensation to the forehead. The medial-most branches of the SON-S crossinnervate the territory of the supratrochlear nerve.[8,9] The SON-D travels lateral to the SON-S, emerging at a more acute angle to the superior orbital rim and remains in the subgaleal plane deep to the corrugator supercilii and frontalis, eventually supplying sensory innervation to the frontoparietal and vertex scalp.

Previous studies have focused on the frontal view course of the SON relative to anatomic landmarks, such as the orbital rim, midline, and midpupillary line to prevent nerve damage during endoscopic brow lift procedures.[1,6,9] Recent interest has also focused on the anatomic relationship of SON branches and the corrugator supercilii because nerve impingement may lead to chronic migraines.[10–12] A dermatologist's detailed understanding of the anatomy and depth of the SON-S is critical for injury avoidance because this nerve is not completely protected under muscle and fascia. To date, no previous anatomic study has quantified the depth of the SON as it courses through the forehead. The purpose of this study is to measure the cutaneous depth of the SON-S as it travels from its origin in the subcorrugator plane to the subfrontalis plane and ultimately to the subcutaneous plane.

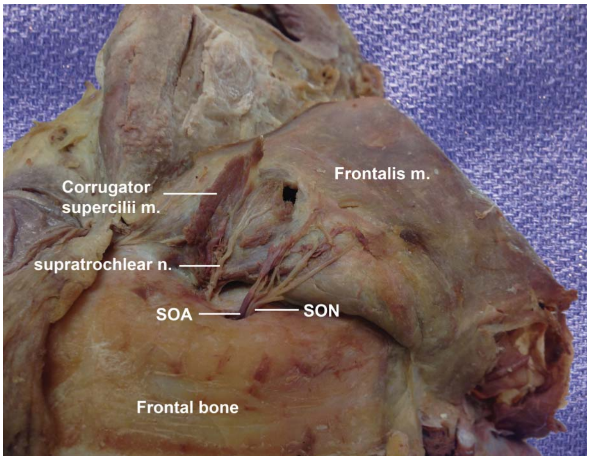

Figure 1. A hemiforehead flap is retracted from the cranial to caudal direction demonstrating the origin of the supraorbital and supratrochlear neurovascular bundles. The corrugator supercilii has been reflected. SOA, supraorbital artery.

Materials and Methods

The Mayo Clinic Institutional Review Board Biospecimens Subcommittee approved the protocol for this study. Sixteen formalin fixed cadaver specimens (32 hemiforeheads) were dissected in the Department of Anatomy, Mayo Clinic. The dissection methods were based on previous publications that measured cutaneous nerve depths.[13–15] Incisions were made along the midline, hairline, and lateral forehead allowing a hemiforehead flap to be elevated from the periosteum in the cranial to caudal direction. This approach allowed the origin of the supraorbital neurovascular bundle to be visualized near the base of the flap (Figure 1). In raising the flap, the authors left the neurovascular structures intact within the flap as a result of the harvesting technique. The original orientation of the flap was maintained when taking measurements relative to anatomic landmarks. The SON was dissected from the inferior side of the flap allowing the overlying muscle, subcutaneous tissue, and skin to remain intact. To accurately measure the cutaneous nerve depth, vertical incisions were made perpendicular to the course of the nerve at the areas of interest to allow an accurate measurement of cutaneous depth from the surface. The horizontal distance from the midline was recorded along with the vertical distance from the palpable superior orbital rim. In each cadaver, a SON-D branch was noted traveling laterally at an acute angle relative to the orbital rim, and a SON-S branch traveling more perpendicular. Both angles were measured and recorded. The SON-S gave rise to multiple branches in all cadavers. These branches transitioned from the initial subcorrugator plane to enter the subfrontalis plane. The vertical distance above the palpable superior orbital rim at which this transition occurred was recorded. When multiple branches were present and transitioned at various points, the median vertical distance was recorded. Once the superficial branches reached the subfrontalis plane, they penetrated into the frontalis to enter the subcutaneous plane. The median distance of this transition point from the palpable superior orbital rim was recorded. The depths of the superficial nerve branches from the cutaneous surface were measured in all 3 planes using the technique described above. All measurements were done with a metric ruler, recorded to the nearest millimeter, and confirmed by 2 independent observers. Nerve branches were dissected under loupe magnification (×3.8).

Results

Sixteen cadavers (7 female, 9 male) were used for a total of 32 hemiforeheads. The average age at the time of death was 87.9 (range, 72–101) years, and the average body mass index was 22.7 (range, 18–27.9) kg/m^2. The origin of the SON was 2.63 ± 0.27 (range, 2.1–3.5) cm from the midline and 0.25 ± 0.16 (range, 0–0.5) cm above the palpable superior orbital rim. In all cases, the SON emerged as 1 root that subsequently divided into the SON-S and the SON-D. The SON-D coursed at an average angle of 50.7 ± 3.0 (range, 45–56) degrees relative to the superior orbital rim and traveled superiorly and laterally toward the vertex scalp. It remained deep to the muscular aponeurosis throughout its course to the scalp.

The SON-S coursed nearly perpendicular to the superior orbital rim at an average angle of 82.2 ± 7.4 (range, 65–90) degrees. The nerve initially traveled under the corrugator supercilii and in this plane had an average depth of 0.75 ± 0.16 (range, 0.5–1.1) cm. The SON-S often gave rise to multiple branches as it traveled in the subcorrugator plane. These branches then transitioned to the subfrontalis plane either by penetrating into the corrugator supercilii or emerging from the superior border of the corrugator supercilii. This transition occurred at a mean distance of 1.29 ± 0.20 (range, 1.0–1.8) cm above the palpable superior orbital rim. The depth of the subfrontalis plane was 0.45 ± 0.13 (range, 0.3–0.8) cm. The SON-S branches then transitioned to the subcutaneous plane by piercing through the frontalis muscle. This occurred at a mean distance of 2.60 ± 0.32 (range, 1.9–3.2) cm above the palpable superior orbital rim. In the subcutaneous plane, the nerve branches had an average depth of 0.30 ± 0.10 (range, 0.2–0.6) cm. As the branches distributed toward the more superficial planes, they became smaller in diameter. The supratrochlear nerve was noted in all specimens and emerged from a separate location medial and inferior to the SON origin (Figure 1). The supratrochlear nerve was noted to be significantly thinner than the SON and often branched directly into the corrugator supercilii.

Discussion

This study offers a quantitative report on the cutaneous depth of the SON as it courses from the supraorbital foramen, across the forehead, and to the scalp. Previous reports describe the anatomic relationship of the nerve in reference to various landmarks such as the orbital rim and midline. Together with these previous descriptions, many of which are corroborated with our data, the results of this study allow for a functional understanding of the 3-dimensional course of the SON (Figure 2, Table 1).

When originating from the skull, the SON may pass through either a supraorbital notch or foramen. A notch is clinically palpable, whereas a foramen is not.[16] Notches and low-positioned foramina have an average vertical distance of 0.1 cm above the orbital rim, whereas high-positioned foramina have an average vertical distance of 0.4 cm and may be over 1 cm above the orbital rim.[17] We found the SON origin at an average vertical distance of 0.25 cm above the palpable superior orbital rim. Although we did not record the percentage of supraorbital notches versus foramina, our relatively short average distance suggested that the majority of cadavers had notches and low-lying foramina.[2,6,16–19]

The average distance of the SON origin from the midline has been reported by previous studies within a range of 1.93 to 3.10 cm.[5–7,9,12,18] Our data fall within this range with an average distance of 2.63 cm. In all cadavers, the SON emerged as 1 trunk that divided into the SON-S (medial) and SON-D (lateral) divisions (Figure 3). Some studies describe a less common variant where this division occurs before the exit from the skull, and hence the SON emerges from 2 separate locations.[5,6,10,16]

At its origin from the skull, the SON is at its greatest cutaneous depth, protected by skin, subcutaneous fat, fibers of the frontalis, and the belly of the corrugator supercilii. Depending on the vertical distance from its origin, the SON may also be partially covered by fibers of the orbicularis oculi.[20] In this subcorrugator plane, we found an average SON depth of 0.75 cm. This agrees well with a previous study by Macdonald and colleagues,[21] characterizing the anatomy of the corrugator supercilii. The authors performed a dissection of 50 hemibrows, measuring the thickness of the corrugator supercilii relative to various landmarks.

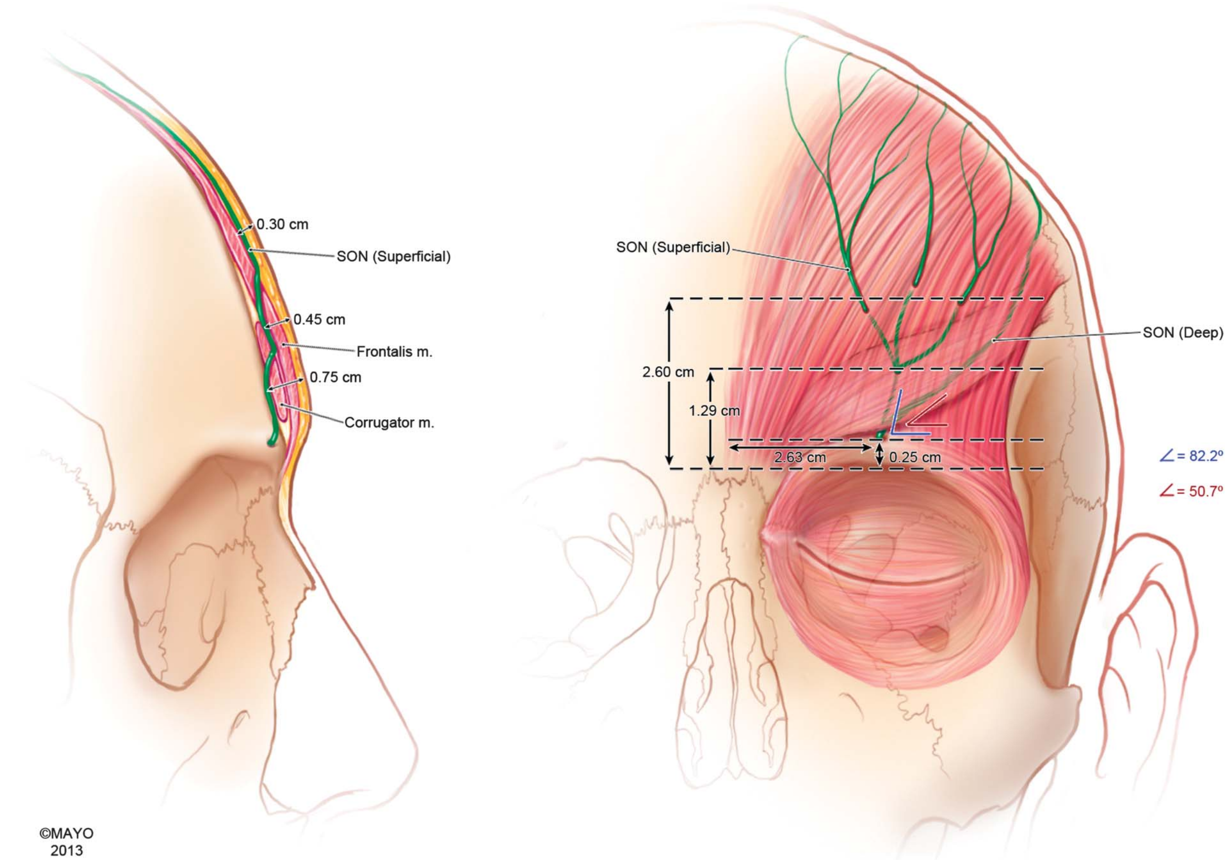

Figure 2. Supraorbital nerve location in three planes.

The anatomic landmark in this study closest to the SON origin is the midpupillary line, where the corrugator supercilii was found to have an average thickness between 0.20 and 0.25 cm. The average depth of the corrugator supercilii was noted to be between 0.40 and 0.50 cm at the midpupillary line, making the average subcorrugator depth between 0.6 and 0.75 cm.

From its deepest origin, the SON divides into the SON-D, which travels acutely relative to the superior orbital rim and stays deep coursing to the parietal

TABLE 1. Location of Supraorbital Nerve Relative to Anatomic Landmarks and Tissue Planes

	SON Origin				*Subcorrugator Plane*		*Subfrontalis Plane*		*Subcutaneous Plane*
	Midline Distance, cm	*Vertical Distance, cm*	*SON-D Angle, degrees*	*SON-S Angle, degrees*	*Depth, cm*	*Vertical Distance, cm*	*Depth, cm*	*Vertical Distance, cm*	*Depth, cm*
Average	2.63	0.25	50.7	82.2	0.75	1.29	0.45	2.60	0.30
Standard deviation	0.27	0.16	3.0	7.4	0.16	0.20	0.13	0.32	0.10
Minimum	2.1	0	45	65	0.5	1	0.3	1.9	0.2
Maximum	3.5	0.5	56	90	1.1	1.8	0.8	3.2	0.6

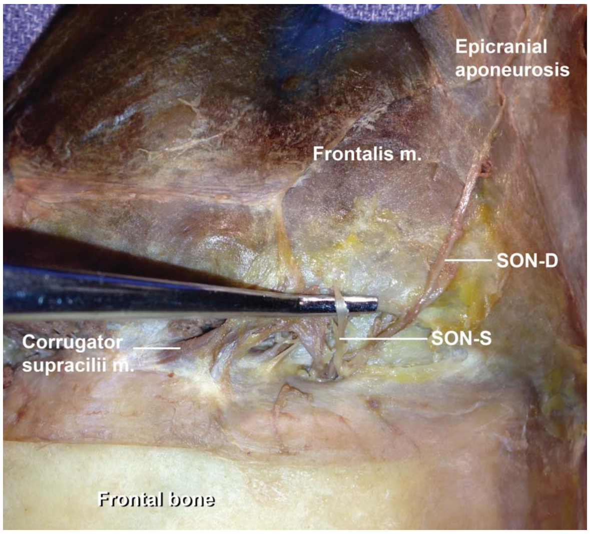

Figure 3. A SON-S branch is identified with the probe penetrating into the frontalis muscle. The SON-D branch courses lateral and deep to the frontalis muscle.

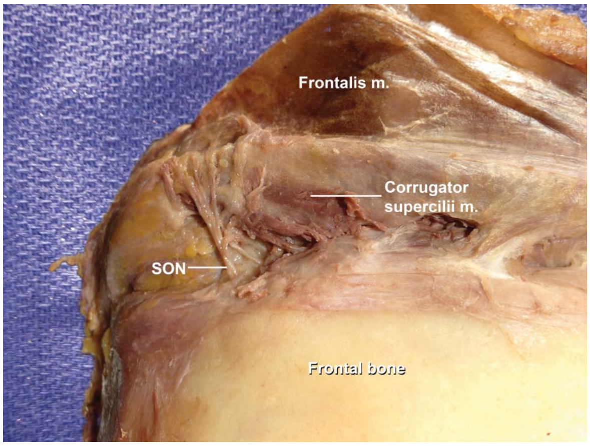

Figure 4. The SON-S branches can be seen traveling under the corrugator supercilii.

scalp (Figure 3). The SON-S travels nearly perpendicular to the superior orbital rim on its course to the frontal scalp. We found the SON-S pierces through the corrugator at an average height of 1.29 cm above the superior orbital rim. This transition was suggested by Park and colleagues in a dissection of the corrugator supercilii in 8 cadavers. The authors describe a branch of the SON consistently piercing through the corrugator supercilii between 1 and 2 cm above the superior orbital rim.[22] Of note, the actual branching patterns of the SON can be quite intricate regarding the corrugator supercilii, and Janis and colleagues[11] published the most thorough description of these patterns. The authors describe 4 types of branching patterns defined by SON branches that course under the belly of the corrugator supercilii and pierce through the muscle. We also observed these various relationships. Often the SON branches fanned out in the subcorrugator level with the various branches entering the subfrontalis plane at different vertical distances above the superior orbital rim (Figure 4).

As the SON-S branches course in the subfrontalis plane, they continue to fan out. The average depth of the subfrontalis plane in our study is 0.45 cm. These branches pierced through the frontalis at various vertical distances above the superior orbital rim, but a median line was identified in each cadaver, and this had an average height of 2.60 cm above the superior orbital rim (Figure 2). These branches then entered the most superficial plane, coursing along the surface of the frontalis (Figure 5). We measured an average depth of the SON on the surface of the frontalis as 0.3 cm with a range of 0.2 to 0.6 cm. This corresponds closely to the frontalis depth measured in McDonald's study ranging from 0.2 to 0.7 cm.[21]

An appreciation for the location and depth of the SON is particularly important for clinicians and surgeons. Skin surgery often causes transection of cutaneous nerves leading to paresthesia around the surgical site as it heals. Fortunately, a rapid recovery of sensation occurs in most areas of the skin because of a diverse

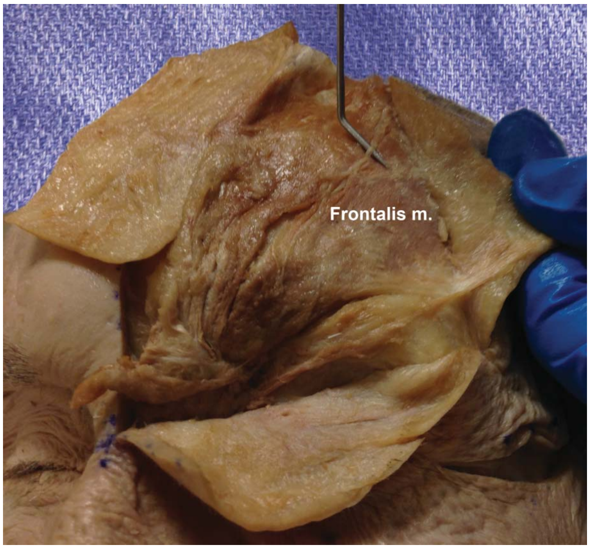

Figure 5. A SON-S branch is identified with the probe running above the frontalis muscle in the subcutaneous plane.

supply of sensory innervation. However, when a major sensory nerve is transected, recovery may take months, years, and sometimes normal sensation never returns.[23,24] Damage to the supratrochlear or supraorbital neurovascular bundles can cause numbness, itching, or formication of the forehead.[25]

Another complication of nerve injury is traumatic neuroma formation. Neuromas present as slowly growing, painful subcutaneous nodules. Recently, traumatic neuroma formation secondary to SON injury has been reported after curettage of an infected epidermal cyst on the forehead.[3] Neuroma formation has also been documented after SON injury during endoscopic brow lift procedures.[4]

One potential limitation inherent to cadaver studies is the possibility of distorting anatomic structures during dissection. The techniques implemented in this study mirrored previous studies that measured cutaneous nerve depth such as Rudolph's study on the facial nerve.[13–15] In our study, anatomic relationships were meticulously preserved during the dissection and while taking measurements. Furthermore, there are normal variations in anatomic structures that reflect individual biologic diversity and may be further influenced by factors such as muscle mass and subcutaneous adipose volume. Notwithstanding these limitations, our study provides a better understanding of a third dimension to the SON course for clinicians to consider when performing procedures on the forehead.

In conclusion, this study demonstrates that, even at its origin from the skull, the SON has a relatively superficial depth and therefore is susceptible to injury during dermatologic procedures. Deep excisions and punch biopsies could reach the nerve because the depth of a standard 4-mm punch biopsy instrument is 8 mm from the hub to the tip (Acuderm Inc., Ft. Lauderdale, FL). As the nerve travels in the cephalad direction, it becomes more superficial. We propose anatomic danger zones around the midpupillary line bilaterally at vertical distances above the palpable orbital rim of 1.3 cm or greater. At these levels, even a deep shave biopsy or exuberant curettage and cryotherapy could lead to SON injury. When performing cutaneous procedures in these danger zones, the clinician should stay as superficial as possible and use blunt dissection when necessary. Additionally, patients should be counseled on the potential for nerve injury in these areas.

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