Review Article
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Clinical anatomy of the superior labial branch of infraorbital nerve

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Abstract: The infraorbital nerve (ION), a branch of the maxillary division of the trigeminal nerve, provides sensory innervation to the midface via its terminal divisions. Among these, the superior labial branch (SLb) supplies the upper lip and adjacent mucosa, regions frequently involved in oral, maxillofacial, and cosmetic procedures. Despite its clinical importance, the anatomy of the SLb has received relatively limited attention compared with other ION branches. This review synthesizes current evidence on the SLb's course, branching patterns, innervation, morphometry, and variations, with emphasis on its relevance to surgical practice. Anatomical studies demonstrate that the SLb is the largest terminal division of the ION, often exhibiting medial and lateral subdivisions that anastomose with neighboring nerves. Its distribution predominantly follows a vertical orientation, supplying both cutaneous and mucosal structures of the upper lip. Variability in origin, branching, and accessory foramina underscores the need for careful surgical planning. Injury to the SLb is a recognized complication of Le Fort I osteotomy, midfacial trauma, and periapical procedures, potentially leading to long-term sensory disturbances. A comprehensive understanding of the SLb enhances intraoperative nerve preservation and may reduce postoperative morbidity, highlighting its significance for clinicians operating in the midfacial region.

Key words: Anatomy, Cadaver, Trigeminal nerve, Oral and maxillofacial, Histology

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Introduction

The infraorbital nerve (ION) is a direct extension of the maxillary nerve that courses through the infraorbital canal. Upon emerging from the infraorbital foramen, it divides into four branches: the inferior palpebral, internal and external nasal, and superior labial branches (SLbs), which provide sensory innervation to the skin of the lower eyelid, external nose, upper lip, cheek, and a small portion of the nasal septum [1, 2]. The ION and its branches are significant structures, particularly in the context of oral and maxillofacial surgery. One notable complication of Le Fort I osteotomy is injury to the ION, which can result in altered or

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diminished sensation in the infraorbital, lateral nasal, and upper lip regions [3]. Such sensory disturbances can affect a patient's quality of life and postoperative recovery. While multiple studies have examined the anatomical variations and branching patterns of the ION [4], much of this research has focused on the main trunk and its major divisions.

However, the distribution and detailed anatomy of the SLb of the ION remain relatively underinvestigated in the literature. This branch is of particular clinical importance due to its role in innervating the upper lip and adjacent structures, areas frequently involved in surgical and cosmetic procedures. A better understanding of the SLb's anatomical course and variability may aid in improving surgical outcomes and reducing the risk of nerve injury. In this review article, we aim to compile and analyze the available data regarding the SLb of the ION. Our goal is to highlight its clinical relevance, particularly in surgical planning and intraoperative nerve preservation in procedures involving the midface region.

The authors state that every effort was made to follow all international and local ethical laws and guidelines regarding the use of human cadaveric donors/tissues and their images in anatomical research [5-7]. The protocol of the study did not require approval by the ethical committees or informed consent. The study followed the Declaration of Helsinki (64th WMA General Assembly, Fortaleza, Brazil, October 2013).

Anatomy

Infraorbital nerve and superior labial branch

The trigeminal nerve is the largest cranial nerve; its maxillary division (V2) innervates the skin and mucous membranes of the midface region, which originates from the maxillary prominence during embryonic development [2, 8]. It runs anteriorly within the infraorbital canal, giving off superior alveolar branches (the posterior superior alveolar branch of the maxillary nerve, and the middle and anterior superior alveolar branches of the ION), which innervate the maxillary teeth. Although it has traditionally been believed that the superior alveolar branches solely innervate the maxillary teeth until Iwanaga et al. [9] found the greater palatine and nasopalatine nerves also innervate the maxillary teeth. Upon emerging from the infraorbital foramen, the nerve divides into four branches; the inferior palpebral branch, internal and external nasal branches, and SLb (Fig. 1). The SLb initially courses deep to the levator labii superioris and superficial to the levator anguli oris, the deepest mimetic muscle of the upper lip (Fig. 2). It then becomes more superficial as it extends to supply the upper lip and labial mucosa [10]. The ION, including the SLb, can also be visualized using ultrasonography as a clustered structure embedded in adipose tissue deep to the levator labii superioris (Fig. 3).

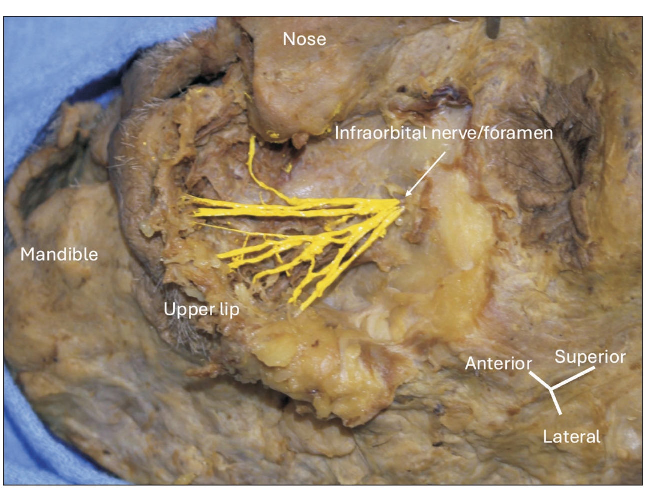

Fig. 1. Anatomical dissection of the superior labial branch of the infraorbital nerve. Note the upper lip is slightly retracted inferiorly to show the nerve branches.

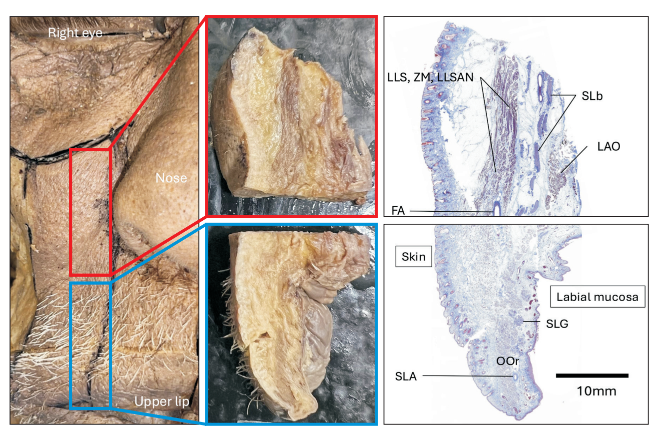

Fig. 2. Histological sample of the superior labial branch of the infraorbital nerve and related structures. Masson's trichrome stain. FA, facial artery; LAO, levator anguli oris; LLS, levator labii superioris; LLSAN, levator labii superioris alaeque nasi; OOr, orbicularis oris; SLA, superior labial artery; SLb, superior labial branch; SLG, superior labial gland; ZM, zygomaticus minor.

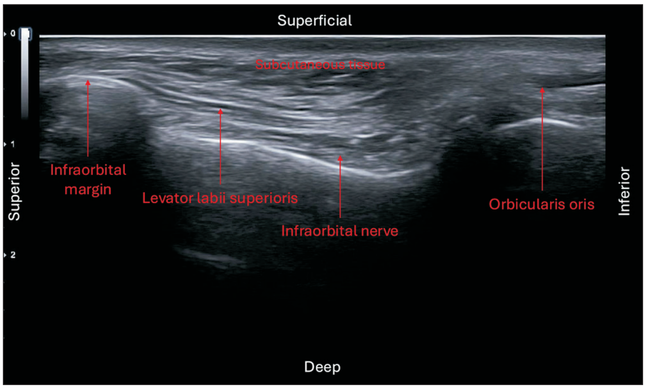

Fig. 3. Longitudinal ultrasonographic image of the infraorbital region. The transducer was placed longitudinally over the left infraorbital area, lateral to the nose and inferior to the infraorbital foramen. In this view, the infraorbital plexus and surrounding adipose tissue, including the superior labial branch of the infraorbital nerve, were observed deep to the levator labii superioris. The ultrasonographic image provides visualization of deep tissues beneath the skin in a noninvasive manner, and can be used to guide procedures such as nerve blocks.

Morphometric studies of the infraorbital foramen and nerve

The distance between the infraorbital foramen and the inferior orbital margin ranges from 4.6 to 14 mm [11, 12]. Hwang et al. [13] reported that the ION gives rise to an average of 19.5 branches (range: 15–24 branches). The mean area innervated by the ION was 25.8 cm^2 (range: 24.0–28.2 cm^2). Among its terminal branches, the SLb supplied the largest area, averaging 13.1 cm^2 (range from 11.2 to 14.3 cm^2), which was notably broader than that of the inferior palpebral branch (7.5 cm^2; range from 6.6 to 8.8 cm^2) and the external nasal branch (7.6 cm^2; range from 6.7 to 9.3 cm^2).

Innervation of the superior labial branch

Hu et al. [14], in their study of 43 hemifaces, found that the SLb of the ION innervated the skin and mucous membranes of the upper lip. In 25.6% of cases, the terminal branches extended from the center of the upper lip to the oral commissure, while in 74.4% of cases, the distribution reached beyond the oral commissure toward the lateral aspect of the mouth [14]. The SLb was further classified into medial branches (medial part of the upper lip) and lateral branches (lateral part of the upper lip) as is done for the inferior labial branch of the mental nerve [15]. In all cases, the small, most lateral divisions of the SLb communicated with the zygomatic branch of the facial nerve.

Autonomic innervation

The ION contains sensory, parasympathetic, and sympathetic fibers. Sensory fibers originate from cell bodies in the trigeminal ganglion, while the parasympathetic fibers are derived from the pterygopalatine ganglion via the greater petrosal nerve, which arises from the facial nerve. The sensory component transmits general sensation from the lower eyelid and conjunctiva, maxillary sinus, maxillary incisors, canines, and premolars, as well as from the nasal cavity, cheek, upper lip skin, and upper labial oral mucosa. The parasympathetic fibers provide secretomotor innervation to the labial glands and mucosa of the upper lip [10]. The sympathetic fibers originate from the superior cervical ganglion and contribute to the external carotid plexus [16]. The fibers should reach the superior labial glands by traveling with the SLb of the facial artery, but the available evidence is limited.

Accessory Infraorbital Nerves and Foramina

While the infraorbital foramen is typically singular, variations in number, ranging from two to three foramina, have been documented. Aziz et al. [11] and Bressan et al. [17] reported that accessory infraorbital foramina were present in 15% and 4.7% (higher frequency on the left side) of cases, respectively. Gupta [18] noted that an accessory infraorbital foramen was found in 1.3%. Berry [19] reported the presence of accessory infraorbital foramina in an English population, with a prevalence of 2.2% in males and 4.8% in females. Since then, numerous studies primarily utilizing dry skulls or cone-beam computed tomography have investigated the prevalence and morphology of accessory infraorbital foramina. Reported prevalence rates vary by study and population, with figures reaching up to 27.3% [20-22]. Iwanaga et al. [23] dissected 60 cadaveric hemi-heads. According to this study, an accessory infraorbital foramen was found in 36.7% of the heads examined. All 12 accessory infraorbital foramina (100%) were medial to the infraorbital foramen. In four cases, accessory infraorbital foramina were associated with small branches of the infraorbital artery that originated within the infraorbital canal and formed anastomoses distal to the main infraorbital foramen. In eight cases, the accessory foramina transmitted nerves arising from the ION within the canal. These accessory IONs included the inferior palpebral, external nasal, internal nasal, and SLb branches in 25.0%, 87.5%, 25.0%, 25.0%, respectively. A communicating branch between the main ION and the accessory ION was

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observed in six of the eight cases (75%). No statistically significant differences were noted between sides or sexes.

Variation

The SLb is the largest terminal division of the ION, giving rise to multiple peripheral subbranches. These subbranches are categorized as medial or lateral, based on their distribution areas [14]. In a study by Nderitu et al. [4], 84 IONs from 42 formalin-fixed cadavers were examined. In 59.5% of cases (n=50), the SLb was unbranched at the point of emergence from the ION. Among these, 35 subsequently bifurcated, and 15 trifurcated. The remaining 40.5% exhibited the classical pattern of two branches emerging directly. These branches further divided before terminating in the skin of the upper lip. Additionally, accessory SLbs arising from separate foramina located inferior to the infraorbital foramen—designated as accessory infraorbital foramina—were observed in 9.52% of the hemifaces. These accessory branches also terminated in the upper lip, similar to those originating from the main infraorbital foramen. Ohshima et al. [24] identified three distinct patterns of anastomosis among peripheral branches of the ION in the upper lip:

1. Type I (44%) - an anastomosis between the internal nasal and medial SLbs
2. Type II (11%) - an anastomosis between the medial and lateral SLbs
3. Type III (44%) - a combined pattern involving anastomoses between the ION and the medial SLb, as well as between the medial and lateral SLbs

Ohshima et al. [24] classified the distribution patterns of the medial and lateral SLbs into the following three patterns.

1. Type a (11%) - the medial SLb supplied both the medial and lateral sides of the oral commissure
2. Type b (55%) - the lateral SLb extended medially to innervate the area near the oral commissure
3. Type c (33%) - the medial and lateral SLbs innervated the medial and lateral sides of the oral commissure, respectively.

The distribution of ION branches in the upper lip follows a predominantly vertical, rather than horizontal, orientation from lateral to medial. Notably, the branching pattern may differ between the left and right sides. Additionally, the SLb may originate from a common trunk shared with the internal nasal branch [25].

Embryology

By the fourth week of embryonic development, the trigeminal nerve (CN V) and its sensory ganglion begin to form from a combination of neural crest cells and ectodermal placodes. The maxillary division (V2) of the trigeminal nerve originates from the maxillary prominence of the first pharyngeal arch, giving rise to the ION and, subsequently, the SLb. This developmental pathway explains the SLb's close anatomical relationship with midfacial structures derived from the same embryonic field, including the upper lip and maxillary alveolus. As the upper lip combines two embryologic components, *i.e.*, philtrum and lateral lip originate from medial nasal prominence and maxillary prominence, respectively, the SLbs show wide innervation patterns corresponding to these territories. Aberrations in neural crest cell migration or infraorbital foramen formation may underlie variations in SLb branching patterns or the presence of accessory infraorbital foramina [26].

Surgical Applications

The ION is at risk of injury during various surgical interventions, including trauma repair, tumor excision, and maxillary osteotomy [27-29]. Alali et al. [30] reported that postoperative neurosensory deficits are significantly associated with reduced patient satisfaction following orthognathic surgery. Numerous studies have emphasized the risk of ION injury during Le Fort I osteotomy due to its close anatomical proximity to the osteotomy line [31]. Traction, retraction, and manipulation during surgery can result in significant neurosensory deficits within the cutaneous distribution area of the ION. These deficits are often bilateral, reflecting the three-dimensional nature of Le Fort I procedures. Factors such as patient age, gender, surgeon experience, surgical duration, and segmentation techniques do not appear to significantly influence the incidence of neurosensory impairment during orthognathic maxillary surgeries [32].

Ueki et al. [33] reported that temporary upper lip hypoaesthesia is an almost inevitable consequence of Le Fort I osteotomy. However, variables such as the osteotomy line, hardware placement (plate/screw position), and pterygoid plate fractures did not affect the duration of recovery, as determined by trigeminal somatosensory evoked potentials. Alolayan and Leung [34] observed that neurosensory recovery progresses over time—fewer than 20% of patients show recovery at two weeks, more than 80% by six months, and over 95% by two years postoperatively.

Al-Din et al. [35] noted that pin-prick, cold sensation, and fine touch returned to preoperative levels in all examined patients within six weeks. Similarly, Schultze-Mosgau et al. [36] reported a temporary ION impairment rate of 81% using standard clinical assessments (sharp-blunt and two-point discrimination), while permanent sensory disturbance occurred in approximately 6% of cases. Notably, most patients exhibited clear signs of sensory recovery within one to three months.

Due to the limited understanding and recognition of the SLb of the ION among oral and maxillofacial surgeons, postoperative complications involving this nerve may be underestimated. For instance, apicoectomy procedures on maxillary anterior teeth have the potential to injure the SLb; however, this risk is often underdiscussed due to a lack of comprehensive anatomical knowledge. A case reported on OsseoNews [37] describes a patient who developed permanent paresthesia of the upper left lip following an apicoectomy on tooth #11, suggesting possible involvement of the ION or its branches.

Recovery after Injury

A peripheral nerve is responsible for connecting the central nervous system to the rest of the body. These nerves are delicate and susceptible to damage. According to Sunderland's classification, peripheral nerve injuries are categorized into five grades, ranging from mild neuropraxia (typically caused by compression) to the most severe injuries involving complete loss of nerve continuity, such as transection or avulsion [38]. The likelihood of nerve regeneration decreases with increasing injury severity, and recovery time is correspondingly prolonged.

Aside from Le Fort I osteotomy, one of the most frequent causes of ION injury is accidental or iatrogenic trauma. Midfacial fractures result in ION damage in approximately 30% to 80% of cases [39]. Clinical symptoms of ION injury include mild numbness, partial sensory loss, complete anesthesia, or dysesthesia, with severity correlating to the degree of nerve damage [40, 41].

Nerve regeneration involves both the regrowth of injured axons and the participation of non-neuronal cells such as Schwann cells, endoneurial fibroblasts, and macrophages. If the neuronal cell body remains intact, the proximal axon may regenerate, growing at an estimated rate of 1–3 mm per day in humans [42]. However, in severe injuries, the potential for spontaneous recovery is diminished and may be incomplete or absent.

For patients experiencing ION injury due to Le Fort I osteotomy or midfacial fractures, conservative observation and reassurance may be appropriate, especially when symptoms such as numbness or pain are present. Lee et al. [43] described a case of Sunderland grade V avulsion injury of the ION following facial trauma, where no microsurgical intervention was performed. Remarkably, gradual functional recovery occurred through conservative treatment and rehabilitation alone. Recovery in such cases is thought to result from regeneration of the proximal nerve segment or compensatory innervation from neighboring sensory nerves, such as the zygomaticofacial, external nasal, or buccal nerves. These observations suggest that even in cases of severe nerve injury where surgery is not feasible, conservative management may still yield functional recovery.

Conclusion

A precise understanding of the anatomy and variations of the SLb of the ION is essential for oral and maxillofacial surgeons, periodontists, and aesthetic practitioners. Awareness of SLb branching patterns, accessory foramina, and potential anastomoses allows surgeons to anticipate anatomical variability, refine surgical planning, and minimize complications. Incorporating this anatomical knowledge into preoperative assessment, intraoperative technique, and postoperative counseling will improve patient safety and optimize functional and aesthetic outcomes.

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Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

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