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LITERATURE REVIEW

A review of the vomeronasal organ in humans: an enigmatic sensory structure

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ABSTRACT

The vomeronasal organ (VNO), sometimes known as Jacobson's organ, is a vestigial anatomical feature in humans whose function and evolutionary relevance remain controversial. While clearly defined and functional in many vertebrates—notably for pheromone detection and behavioural regulation—its role in humans is ambiguous. This review consolidates current morphological, histological, neurological and clinical findings about the VNO, while emphasising developmental trends and population-specific data. Drawing on historical studies, molecular biology and comparative anatomy, we aim to offer a comprehensive perspective on the VNO's presence and potential roles in human biology.

KEYWORDS: vomeronasal organ, pheromones, olfaction.

INTRODUCTION

The vomeronasal organ (VNO) has long fascinated anatomists, evolutionary biologists and clinicians. First noted by Frederik Ruysch in the 18th century and later described in detail by Ludwig Jacobson in 1813, the VNO was originally believed to be rudimentary or absent in humans[1,2]. Kölliker's histological studies of fetal tissue confirmed the embryonic presence of the VNO, renewing interest in its persistence into adulthood[3]. Subsequent inquiries have focused on anatomical conservation, histological differentiation and the potential for functional receptors in adult humans.

INCIDENCE

The occurrence of the vomeronasal organ in humans has been studied across diverse populations, with prevalence rates differing according to age, methodology and geographic location. A Bulgarian research analysed 296 adult cadavers and identified the VNO in 26.7% of instances[1], predominantly unilaterally. An anatomical investigation in the United States found the VNO in 36% of 123 cadaveric specimens, predominantly on the left side[4], although a separate developmental study indicated a higher incidence in newborns and children, which regresses with age[3].

In Egypt, researchers identified the organ in 28.2% of 124 adult cadavers, with a minor inclination towards female preponderance[5]. In contrast, research from Canada and France indicated significantly greater prevalence rates, with Canadian investigators recognising the VNO in 100% of 27 cadavers[6], and the French study observing it in all 534 living persons by endoscopy and histology[7]. A comprehensive investigation in Mexico identified the VNO in all 1,000 surviving participants studied, with bilateral occurrence in 89% of instances[8]. In Brazil, the VNO was identified in 92% of 100 adult cadavers[9].

Fetal investigations conducted in India revealed that the organ was bilaterally present in all 40 fetal tissues analysed microscopically.

Collectively, these findings indicate that although the VNO is almost universally present in early human development, its detectability in adults varies and is affected by regional, anatomical and methodological factors[10].

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EMBRYONIC DEVELOPMENT AND POSTNATAL PERSISTENCE

The VNO begins as a bilateral invagination of the nasal epithelium early in embryogenesis. During the fetal period, it connects to the nasal cavity via a duct and is supported by Jacobson's cartilage[11]. By the second trimester, it appears as a defined duct with glandular and neuronal characteristics. Postnatal studies reveal variability: while most neonates show identifiable VNO structures, adults often display vestigial or regressive forms.

Jacobson's cartilage remains a reliable anatomical landmark. Although the lumen is often occluded and the epithelium lacks sensory specialization, certain cases reveal structural persistence[12].

HISTOLOGICAL FEATURES

Histologically, the VNO is lined with pseudostratified columnar epithelium, comprising sensory neurons and sustentacular (supporting) cells. Sensory neurons bear microvilli and extend axons through the basal lamina[13]. In animals, these neurons express vomeronasal receptors (V1Rs and V2Rs) and use G-protein-coupled signalling. In humans, these receptors are mostly pseudogenised[14].

The underlying lamina propria includes blood vessels, connective tissue and mucous glands. Some vestigial VNOs retain these glands, raising questions about residual functions.

NEUROANATOMICAL AND COMPARATIVE INSIGHTS

In functional species, sensory input from the VNO is processed via the accessory olfactory bulb (AOB), with projections to the limbic system, including the hypothalamus and amygdala. This system mediates pheromone-driven behaviours. In humans, the AOB is either absent or rudimentary. In contrast, the main olfactory system remains fully functional, highlighting the reduced role of the VNO[12].

MOLECULAR AND GENETIC CONTEXT

Pheromones are chemical signals that provoke behavioural or physiological reactions in individuals of the same species. In numerous mammals, pheromones are predominantly detected via the vomeronasal organ (VNO), eliciting instinctual responses such as mating, aggression and social bonding[15,16]. The function of pheromones in humans is a subject of significant contention. Although some studies indicate that specific compounds—such as androstadienone and estratetraenol—might affect mood, hormonal levels, or perceived attractiveness, the underlying mechanism of action is ambiguous, especially in the absence of a fully operational vomeronasal organ (VNO)[17]. The primary olfactory system may mitigate this sensory deficiency; nonetheless, the degree to which humans utilise pheromones for communication remains predominantly conjectural[18]. Nonetheless, the possible behavioural influence of such cues necessitates additional interdisciplinary investigation.

Genomic studies show widespread pseudogenization of vomeronasal receptor genes (V1Rs, V2Rs) in humans. Transient receptor potential canonical (TRPC2), a key ion channel in VNO signalling, is a pseudogene in humans, reinforcing the argument for functional regression. However, traces of gene expression in specific epithelial regions suggest possible non-sensory roles, including paracrine or endocrine signalling. Some evidence also points to involvement in gonadotropin-releasing hormone (GnRH) migration during development[14].

CLINICAL IMPLICATIONS

The vomeronasal organ is frequently regarded as vestigial exhibits discernible anatomical characteristics in a considerable number of individuals and retains therapeutic significance, especially in nasal examinations and septal interventions. The VNO pit, a tiny mucosal depression, is predominantly situated in the anteroinferior third of the nasal septum, integrated into the septal mucosa (Figure 1), typically 1–2 cm above the nasal floor[11]. Endoscopic investigations, such as those conducted by Trotier et al.[7], have revealed that the VNO pit may be imperceptible during examination in certain individuals; however, they documented the presence of at least one visible VNO pit in 92% of non-operated subjects.

The organ is morphologically characterised as a blind-ended tubular sac with an average diameter of 0.2–0.6 cm and a depth of about 2 mm. Reported positional variations range from 1–3 mm above the nasal floor to 6.2–10.7 mm above the palatine crest, and 7–10 mm from the nasal base, contingent upon the anatomical reference point employed. This positional variability may indicate genuine interindividual variances as well as methodological problems, such as the misidentification of neighbouring or non-homologous structures that resemble the VNO[3,7]. Furthermore, the morphology of the VNO aperture is variable. Zbar et al.[19] categorised it by dimensions, but Besli et al.[20] recognised oval, fissural, and elliptical configurations. Due to these inconsistencies, numerous studies, notably Johnson et al., have advised against exclusively depending on macroscopic anatomical landmarks for VNO diagnosis[6].

Clinically, although the vomeronasal organ in humans is devoid of the sensory neurones and accessory olfactory structures required for pheromonal communication, recognition of its existence and variability is crucial for nasal diagnoses and surgical planning (Figure 1). Additional study employing standardised imaging and histology techniques

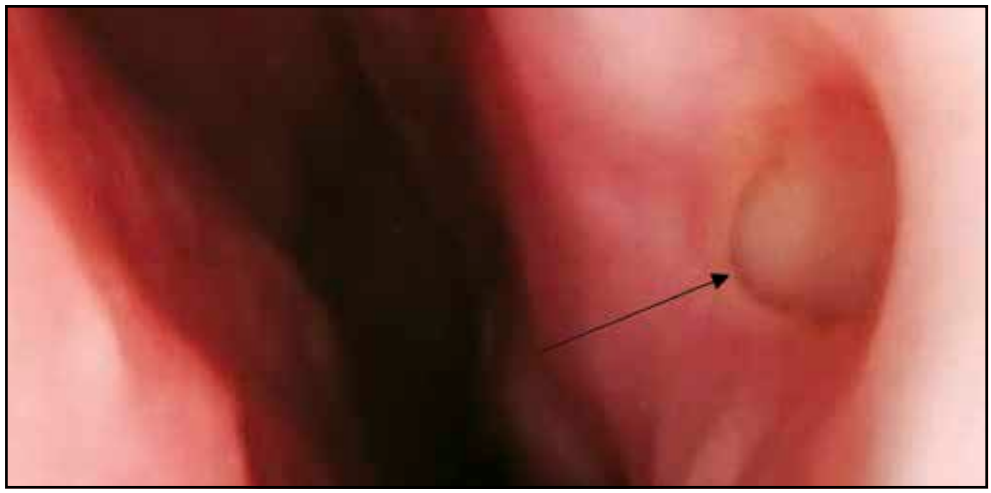

Figure 1. Vomeronasal organ situated on the right side of the nasal septum (black arrow) –endoscopic view.

is required to clarify persistent discussions over its functional significance and anatomical uniformity in the adult demographic[21].

While its injury is typically inconsequential, anatomical awareness is important to avoid unnecessary damage. Rarely, tumours or polyps may arise near or from vomeronasal remnants, necessitating histological vigilance[22]. Teaching about the VNO also enriches anatomical and evolutionary education.

POPULATION-BASED AND REGIONAL OBSERVATIONS

Research on VNO variability among different populations is sparse. The organ's detectability in adult humans exhibits significant variability between populations and techniques, spanning from 26% to nearly 100%, with increased prevalence observed in early life and in specific regions such as Mexico, Brazil and France. These findings underscore the significance of standardised methodologies and cross-population analyses in evaluating anatomical incidence[1,3,5-9].

Romania, with its diverse ancestry and geography, presents a promising context for future morphological and genetic studies. Regional investigations may reveal differences in VNO structure, persistence, or molecular activity, offering insights into olfactory-related congenital disorders and evolutionary biology.

CONCLUSIONS

The vomeronasal organ, often deemed a vestigial remnant, demonstrates significant anatomical durability throughout human foetal and neonatal stages. Although its sensory capabilities seem restricted—attributable to the pseudogenisation of essential receptor genes and the lack of a specialised auxiliary olfactory bulb—evidence indicates that the vomeronasal organ may nonetheless fulfil non-chemosensory functions, especially during embryonic development and in neuroendocrine signalling pathways.

Although the human vomeronasal organ may not play a substantial role in pheromone-driven behaviour, its persistent embryological existence and rare postnatal retention merit additional scrutiny—particularly within the realms of developmental biology, evolutionary medicine, and congenital olfactory diseases.

Future research that combines molecular genetics, neuroanatomy and clinical imaging may clarify whether the human vomeronasal organ possesses latent functions or is entirely vestigial. Simultaneously, understanding the anatomy of this component is crucial during nasal and septal surgeries, underscoring its significance in clinical practice and anatomical education.

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